Market Research Report

Commercial and Industrial Lighting Study, Volume 1

prepared by

Xenergy, Inc.

with assistance from

Rising Sun Enterprises
Pacific Energy Associates
Energy Market Innovations

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NORTHWEST ENERGY EFFICIENCY ALLIANCE
www.nwalliance.org

529 SW Third Avenue, Suite 600
Portland, Oregon 97204
telephone: 503.827.8416 • 800.411.0834
fax: 503.827.8437

COMMERCIAL AND INDUSTRIAL LIGHTING MARKET RESEARCH STUDY

FINAL REPORT

Volume I

Prepared for

Northwest Energy Efficiency Alliance
Portland, Oregon

Prepared by

XENERGY Inc.
Oakland, California

with assistance from

Rising Sun Enterprises (Robert Sardinsky and Jim Benya)
Pacific Energy Associates
Energy Market Innovations

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E EXECUTIVE SUMMARY

This report presents the results of a comprehensive market research study (the Study) focused on the commercial and industrial (C&I) lighting industry of the Pacific Northwest (PNW) conducted on behalf of the Northwest Energy Efficiency Alliance (the Alliance). The information and recommendations presented in this report will aid the Alliance in determining whether to develop a set of initiatives tailored to the unique needs of the region's C&I lighting market. Although the scope of this study includes only research on C&I lighting, readers should be aware that the Alliance is analyzing whether C&I lighting should be addressed through lighting-specific initiatives, lighting-related activities that are integrated parts of a broader whole-building initiative, or some combination of the two. Also note that the research presented in this report is intended by the Alliance to be a broad *first-step effort* from which additional market research efforts may follow.

E.1 ALLIANCE OBJECTIVES

In conceiving this Study, the Alliance had three overarching and closely intertwined objectives:

1. Characterize the current market for C&I lighting products and services in the PNW,
2. Assess the merits of lighting technologies and practices that go beyond current standard practices; and
3. Provide suggestions for new Alliance initiatives in the C&I lighting market.

E.2 OVERVIEW OF STUDY SCOPE

Like any study, the Study objectives and research questions needed to be prioritized, given the resources allocated and the fast-paced project schedule. The study combined primary research, secondary sources, and the knowledge of industry experts to produce a product that would be the key first step in the Alliance's new C&I initiative development process.

Among the three objectives presented above, the bulk of the project resources were allocated to the first one, developing a market characterization specific to the Pacific Northwest. This market characterization was developed principally from over 120 in-depth interviews conducted with supply-side market actors in the PNW.

The second objective, assessing new C&I lighting opportunities, was examined through use of lighting experts on our project team and their use of secondary sources. This effort represented about 20 percent of the project resources and resulted in the products presented in *Section 6 - Promising Technologies and Practices* and several of the appendices.

The last key objective, to assess and develop new initiatives, was addressed through a combination of summarizing initiatives currently being implemented or considered by organizations other than the Alliance, and several structured brainstorming sessions.

E.3 STUDY APPROACH

The key research activities employed for this study included the following:

- primary research consisting of in-depth interviews with regional market actors and lighting experts;
  - ⇒ 60 distributor interviews
  - ⇒ 30 designer interviews (architects, electric engineers, and lighting designers)
  - ⇒ 30 installer interviews (principally electrical contractors)
  - ⇒ approximately a dozen regional and national lighting expert interviews
- secondary research consisting of detailed review and utilization of lighting studies relevant to the Study objectives;
- utilization of the knowledge of our project team's lighting experts; and
- analysis of initiatives being implemented elsewhere in the United States and structured brainstorming of prospective new initiative needs.

E.4 SUMMARY OF KEY BASELINE FINDINGS

The lighting market is changing in the Pacific Northwest. What used to be a region in which the densely populated cities in the western parts of Oregon and Washington had substantially more efficient lighting has changed into an area where many proven high-efficiency lighting technologies have migrated east to Idaho and Montana, despite a lack of mandatory energy codes in those states. There are several general conclusions that we summarize below about the current state of the lighting market in the Alliance's territory:
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DESIGN INFLUENCE Electrical engineers are most influential over choices in lighting equipment, controls and layout. In addition, electrical contractors make design suggestions and changes in one-third of all projects. Despite this, electrical engineers and contractors are generally not trained in daylighting, and rarely get involved early in a project when daylighting opportunities are greatest.

REGIONAL SIMILARITY The use of efficient lighting equipment is not significantly different in the population centers west of the Cascades and in the more rural eastern areas of Oregon, Washington, and the states of Idaho and Montana. Emerging technologies are used in greater numbers in Seattle and Portland, but as with occupancy sensors, T8 lamps, and electronic ballasts, these quickly spread to eastern areas as they are proven.

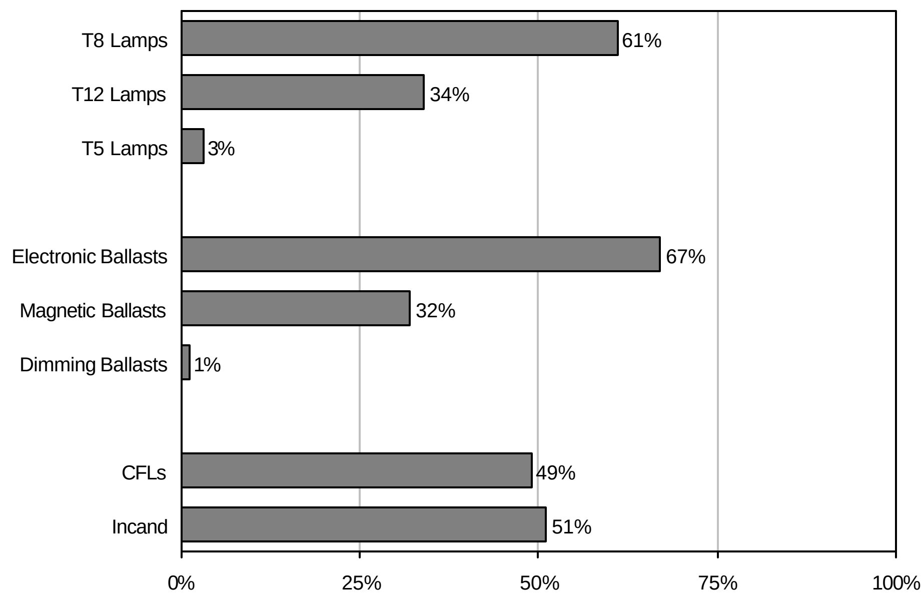
ELECTRONIC BALLASTS Electronic ballasts are now standard practice. For new purchases that serve both existing and new buildings, distributors report that electronic ballasts made up 67 percent of sales in 1999 versus 43 percent in 1996. In new construction, electronic ballasts represent an even higher share, roughly 82 percent according to a related Alliance study.

T8 LAMPS T8 lamps are also considered standard practice. From 1996 to 1999, sales of T8 lamps jumped from 34 percent to 61 percent of the four-foot fluorescent market.

CFLS Compact fluorescent lamps have gained considerable market share over the past three years, jumping from 32 percent of downlights and wall sconce sales in 1996 to 49 percent in 1999.

A summary of the current penetration estimates we developed from our primary research is shown in Figure E-1.

Figure E-1
Current Product Market Shares for New Purchases - Distributor Self-Reports



While there are many more lighting specialists in Seattle and Portland than in Spokane and Boise, lighting designers throughout the Alliance's territory are concerned about the increasing speed of construction. Concerns center on the lack of time available to design good lighting systems. Some designers noted that the problem is exacerbated in design-build projects because of the emphasis on rapid completion. One of the results of rapid construction is a shift toward modular lighting designs which are copied onto new floorplans, often without regard to building orientation, window size and placement, or lighting in surrounding spaces.

Other important baseline results of this study address market structure, practices of the professionals, lighting technology trends, key information sources, and the awareness and use of the Lighting Design Lab in Seattle. These include:

On practices:

- Most designers report using hand calculations and rules-of-thumb for their lighting designs, few use sophisticated modeling tools, though several computer simulations are sometimes used as well.
- Some attention is getting paid to comfort and productivity associated with lighting, but mostly by a small vanguard of architects and designers.
- Interest in daylighting is significant, but its application is still very uncommon.
- Knowledge of fundamental daylighting design principles is limited to a small group of designers, most designers honestly rate themselves poorly with respect their knowledge of how to effectively use daylighting to reduce electrical lighting consumption.

On technologies:

- Penetration of occupancy sensors is still limited, market actors continue to have concerns about the use of these controls.
- Pulse-start metal halide fixtures are widely known and are increasingly used.
- LED exit signs have nearly replaced CFL and incandescent units in new construction.
- T5 lamps will increase market share in mainstream applications in the next three years. Many designers and distributors regard T5 lamps as an “up-and-coming” technology.
- There are more choices of fixtures with efficient lamp and ballast configurations than there were in the recent past.

On the key information sources:

- Manufacturers and trade magazines are the principal sources utilized by supply-side actors to obtain information on new technologies. Electrical distributors and trade shows were also cited as important sources of new technology information.
- The World Wide Web was not cited as a key source by distributors or contractors, but was cited as such by designers.
- The Lighting Design Lab was cited as a key source of new technology information by about 12 percent of respondents.

On the Lighting Design Lab:

- An impressive 80 percent of designers, 59 percent of installers, and 75 percent of distributors are aware of the Lighting Design Lab.
- Almost a third of all respondents report visiting the Lab or using its services (including regional outreach services).

E.5 PROMISING C&I LIGHTING TECHNOLOGY AND PRACTICES AND REGIONAL POTENTIAL

The first-tier technologies and practices found to be most promising in this study are:

- Energy effective lighting design (non-daylighting)
- Daylighting by design
- Fluorescent dimming
- Integrated lighting controls
- Halogen IR sources
- High efficiency generic fluorescent fixtures
- T5 and T5HO fluorescent luminaires
- Modern metal halide lamp/ballast systems
- Modern industrial fluorescent systems
- High efficiency compact fluorescent luminaires

Descriptions of these technologies and practices, along with the opportunities they present and barriers to their increased market penetration are provided in Section 6 of this report.

As part of this study, we developed rough estimates of the potential savings that could be achieved by 2010 by increasing the penetration of efficient C&I lighting technologies. There are several important caveats associated with these estimates that readers should review in Section 6.3. Also note that all of the potential estimates presented in this report are only approximate, as a full potential analysis was not within the scope of this study.[1] Our objective for developing potential estimates in this study is modest: it is simply to provide the Alliance with a general sense of the available potential so that it can take the relative potential of the lighting market into account when comparing the C&I lighting initiative area with other opportunity areas it may be considering.

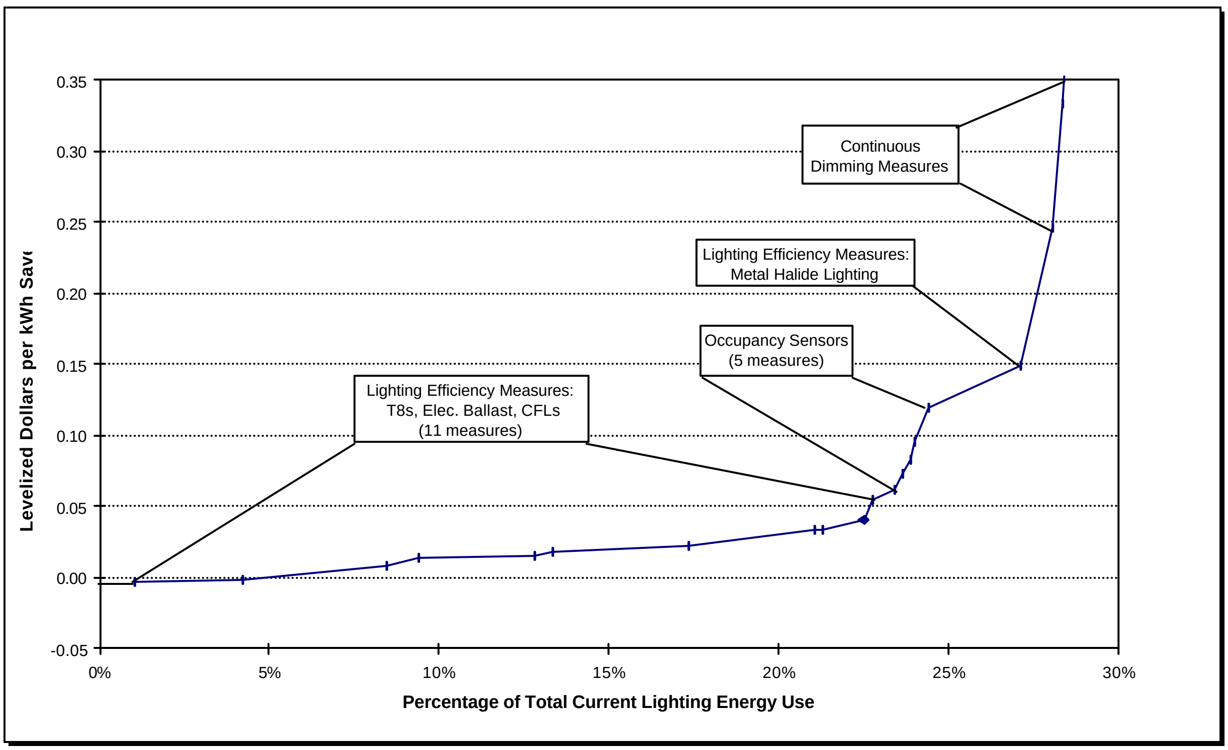
In the existing construction market, we estimate that, in terms of energy savings, there is roughly 30 percent of technical and at least 17 percent of economic potential remaining in the existing construction lighting market. Importantly, the economic potential could be significantly higher depending on avoided costs. Figure E-2 presents a supply-curve of remaining potential in the region. The economic potential increases to about 23 percent if the levelized cost threshold moves up from about 2.5 cents per kWh saved to 5 cents per kWh saved. Also note that most of the remaining economic potential is associated with T8 lamps/electronic ballasts (T8/EBs) and compact fluorescent

[1] XENERGY has conducted dozens of energy-efficiency potential studies. These studies require extensive analysis of measure costs, savings, baseline population forecasts, and saturations of existing equipment, and the like. As a frame of reference, consider that the budget resources applied to most energy-efficiency potential studies equals the entire budget of the current study. Estimating the total potential of lighting savings in the current study, however, represents only a small portion of the total scope (less than 5%).

lamps (CFLs). Occupancy sensors are somewhat above the 5 cent per kWh saved leveled cost when considered on the margin (that is, after implementation of T8/EBs and CFLs. In addition, since the supply curve analysis is based on the average hours of use for lighting within each building type, it does not fully capture the economics of occupancy sensors which are most cost effective when applied to the portion of space with operation hours that exceed occupancy and other needs.

On the margin, retrofitting to perimeter dimming is very expensive from an energy-only point of view. This finding is consistent with analyses conducted by XENERGY and others in previous economic potential studies. Societal economics for perimeter dimming are very sensitive to the value associated with peak (daytime) demand reduction, while customer economics are equally sensitive to whether the value of peak demand reductions is translated into end user price signals. Without high on-peak price signals, perimeter dimming is generally not cost effective for customers on a retrofit basis.

Figure E-2
Commercial Sector Lighting Supply-Curve* - Existing Stock, Base Year = 2000

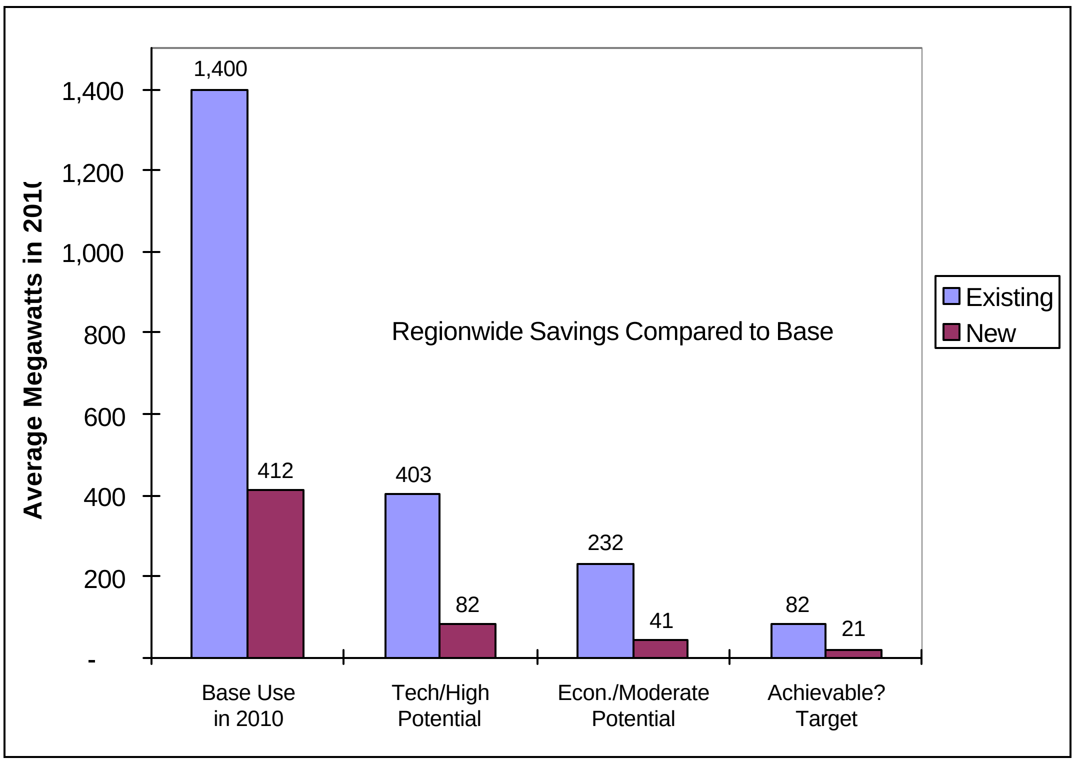


For the new construction market, we estimate that a 10 percent improvement in lighting power density across all commercial building types would result in approximately 41 aMW of savings by the year 2010, while a 20 percent reduction, which would require extensive use of controls and daylighting, would produce 82 aMW of savings over the same period.

Although estimates of the total potential available are important for planning purposes, it is important not to mistake technical and economic potential for what is achievable in the market through program initiatives. Detailed estimation of market and program potential are beyond the scope of the present study, however, we have provided a hypothetical example of what an achievable potential target might produce. In Figure E-3, we include a hypothetical case in which a 5 percent improvement in lighting use is achieved in new construction and one-third of the remaining economic potential in the existing market is captured. The result would be savings of 21 aMW in the new construction market and 82 aMW in the existing market, for a total of 103 aMW by the year 2010.

Over the next 10 years, the existing construction market still holds the majority of the remaining savings potential in the region; however, influencing the new construction market is also critical because of the importance of avoiding lost opportunities and the opportunity to build best practice design into the building design process when it is least expensive and most advantageous to maximizing lighting savings.

Figure E-3
Overall Summary of Commercial Lighting Potential and Hypothetical Target - 2010



E.6 MARKET BARRIERS TO "NEXT LEVEL" C&I LIGHTING

There are a host of challenges inherent in the types of opportunities associated with harvesting the remaining lighting savings in the PNW. This is because the greatest remaining opportunities, given technologies available today, or expected to be available in the near term, are design related, and C&I lighting design is fraught with barriers to further improvement. Key barriers discussed throughout this report include the following:

1. ***Design cost minimization***. Building developers/owners/financiers are usually unwilling to increase building budgets to accommodate the added costs of daylighting. Owners and developers generally seek to minimize design and commissioning costs.
2. ***Control technology cost, ease-of-use, reliability, and reputation***. Lighting controls for daylighting are an immature market and require new products and new thinking. In the meantime, the complexity of the current products, magnified by the variations in dimming ballasts, demands much greater design costs and much greater commissioning costs. Even occupancy sensors still suffer from concerns over reliability and maintenance requirements.
3. ***Lack of design/build integration (i.e., linear and fragmented design process).*** Lighting designs that make use of natural light are stifled by the traditional linear approach to design. Most significant architectural programming is completed before the electrical engineer or lighting designer is brought on board, seriously cutting the opportunities for including daylighting provisions in the building shell plan.
4. ***Pervasive lack of professional knowledge***:
   - ⇒ Electrical contractors are generally unfamiliar with dimming and daylighting control systems and prefer to avoid them. Electrical contractors *perceive* these new systems as an order of magnitude increase in warranty service and call-backs. These contractors may deliberately seek to kill or remove dimming systems, often under the guise of "value engineering." Contractors in our study also cited concerns about reliability, maintenance and customer override as significant barriers to their use of occupancy sensors.
   - ⇒ General contractors are extremely conservative and risk averse, e.g., a market actor for whom "all skylights leak."
   - ⇒ Architects tend to be poorly trained in the use of daylighting and generally do not consider lighting systems in their purview.
5. ***Use of rules of thumb and templates dominate.*** As discussed in Section 5, designers report using hand calculations and rules of thumb most often to layout fixtures, though they do not report using templates as much as hypothesized.
6. ***Lack of end-user demand for advanced lighting design and daylighting***. Electrical engineers, architects, and lighting designers stated that they were asked by their clients in less than three percent of cases to include daylighting in their designs. Despite recent advances in documenting the energy and non-energy benefits of daylit buildings, the message has not yet effectively penetrated and affected the key end user decision makers.

E.7 Suggested Initiative Areas the Alliance Should Consider

E.7.1 Philosophical Considerations

Before discussing the initiative areas specifically, we present a summary of our general guidelines on how the Alliance should approach improving the current C&I lighting market.

Establish A Realistic High-Level Goal And Timeline. The Alliance should have a clear, overall goal in mind before embarking on specific initiatives in the C&I lighting market. For example, the Alliance may want to target a 15 percent improvement in total regional lighting use over current standard practice. *In addition, it will be critical for the Alliance to determine the relative priority of energy versus peak demand savings*. If demand savings are important, or grow in importance (as implied by peak summer wholesale prices in the western U.S.), then the societal value of peak reducing opportunities will increase accordingly (this is especially critical because the premium price of dimming ballasts currently prevents them from being cost-effective under flat marginal cost forecasts).

Take A Measured Approach To Developing New Initiatives. Because it will be difficult to reduce the market barriers discussed in this report, we believe that a *measured*, gradual approach to changing the market is needed. In the short term, trying to rapidly change this particular market with one or a combination of large initiatives could backfire from implementation of immature technologies, the misapplication of technologies by untrained professionals or the like.

Get Direct Market Actor Feedback And Thoroughly "Road Test" Prospective New Initiatives. The Alliance has shown itself to be a national leader in developing, testing, assessing, improving, and culling energy efficiency programs. We applaud this and suggest that the Alliance continue its general approach and orientation to program development as it tackles C&I lighting.

Mix And Match Cross-Market And Target-Market Programs And Messages. Although we have not determined which of the suggested initiatives the Alliance should pursue, we believe that a combination of initiatives that address both general and specific market barriers will be necessary. In particular, a combination of increasing demand from end users/building owners and improving product/practice supply will be critical.

Leverage The Good Work Of Others And Fill Gaps Selectively. As shown in Section 7.3, there is a small renaissance of activity around the country aimed at bringing C&I lighting design to the next level. This is trend promising and provides an excellent platform upon which the Alliance can build its own complementary and region-specific programs. A cautionary note is that most of these initiatives have been in existence only a short time and, as such, do not yet have much in the way of evaluation results available to demonstrate their efficacy and improvement in their approaches.

Make Buying Quality and Efficient Lighting More Of A Commodity Purchase. For the low-end market, but also for higher-calibre designers, explore the extent to which efficient, quality lighting can become routine, through use of standard methods, templates, equipment standards, quality guidelines and other tools.

E.7.2 New Initiative Areas the Alliance Should Consider

In Section 7 of this report, we discuss a number of prospective initiative areas for the Alliance to consider. Within the scope of this study, we have not prioritized among these considerations. To prioritize among them requires estimation of the costs and benefits of carrying out each of the initiatives.

This information could be developed independently through additional research or through a competitive bidding process in which bidders are required to forecast and commit to specific milestones and impacts, or through a combination of both. The recommend areas to consider are as follows:

Lighting Design Tools. Development And Dissemination of Lighting Design Guides, Software Tools, And Templates. This is currently a popular area of emphasis among lighting programs nationally—so popular in fact, that there is now an almost overwhelming array of design guides currently available or under completion. Some experts believe that the bulk of the current suite of guides and software tools are more appropriate for the "high" end of the supplier market than the "low" end. As a result, one suggestion that has come up in several of the brainstorming sessions held to support this aspect of our research is to develop a set of best practice lighting design templates that would support the "lower" end market events and market actors.

Development And Dissemination Of Case Studies. This is another area, like the one discussed above, in which a great deal of progress has been made recently around the country. Most of the initiatives for which there are high-end design guides also are developing case studies. The Lighting Design Lab also provides some case studies to visitors, as does the "Field Studies" portion of the BetterBricks.com website. The Alliance should assess whether the current set of case studies, and associated dissemination mechanisms, from these sources are adequate to meet the region's need.

Stimulation of End User/Building Owner Demand, Support For Non-Energy Benefits Demonstration Research, And Leveraging of Growing Interest In Green Buildings. Although we do not believe there are any silver bullets currently available to rapidly increase end-user and building owner demand for best practice lighting, we believe that, ultimately, this is perhaps the most critical dimension of the problem. As we have stated in related market transformation studies and publications: *end users are the demand engine upon which virtually all self-sustaining changes in the marketplace are dependent*.

A popular current approach to this problem as it pertains to C&I lighting is demonstration and communication of the non-energy benefits of daylighting and advanced lighting design, especially those that pertain to productivity increases. The arguments in favor of this approach are powerful and the fruits of initial efforts to quantify these benefits are emerging.

Another approach the Alliance should consider is focusing on real-estate investment trusts (REITs). These organizations own and manage a large percentage of the commercial floorspace in the United States. By reaching and influencing the largest of these organizations, a significant percentage of square footage and lighting load can be affected.

We also believe that the current growing interest in green buildings, especially in the PNW, represents an important opportunity to advance best practice lighting in the region. Green buildings also tend to be marquee buildings (e.g., corporate and government headquarters, historic sites, etc.). Thus, green buildings may diffuse best practice energy and lighting approaches more quickly than would other buildings. The Alliance should seek to ensure that green building candidates adopt best practice lighting (especially, daylighting) and that these cases be well publicized through the appropriate communication channels.

Product Catalogues And Guides/Distributor-based Initiatives. The areas discussed above target most of the key market actors with the exception of distributors and manufacturers. In addition, the initiative areas discussed previously are mostly design-related. Another area that the Alliance should consider is the promotion of high-efficiency lighting products at the distributor level of the value chain. Although basic high-efficiency components are now generally available from most distributors (e.g., electronic and even dimming ballast, T8 lamps, and CFLs), some of the higher end efficiency products are not well stocked or promoted by distributors.

Education Of Current Practitioners. In this study, even market actors most responsible for lighting design self-rate their knowledge level of daylighting-related practices between 'not very familiar' and 'somewhat familiar'. Importantly, no one we spoke with (out of 120 interviews) reported having *expert* knowledge of daylighting. Consistent with this finding, when these market actors were asked for their own suggestions of initiatives the Alliance should pursue, the most commonly mentioned area was education.

Education Of Future Practitioners. Many lighting experts and program administrators believe that to achieve long-term, lasting change in lighting design practices, fundamental improvements must be made in the academic education of architects and electrical engineers. However, there is no consensus on this issue. Some experts believe that academic training is of secondary importance to on-the-job experience and training because the commercial demands placed on practitioners make a more consistent, lasting impression on designers than academic courses.

Evaluate Need For Code Improvement. The Alliance recently sponsored a baseline study of nonresidential new construction practices in the PNW.[2] This study indicates that high-efficiency components, in particular, T8 lamps with electronic ballasts, metal halide, and CFLs, dominate the market, although incandescent and standard efficiency 8-foot lamps are still common. Thus, codes appear to be doing their job effectively with respect to basic high-efficiency lighting components. However, the same study also shows that dimming and related daylighting systems were not penetrating the market as of 1998 (which we confirm with the results in Section 5.7 of this report). Facilitating advanced design practices through energy codes is not easy, however. Further investigation into whether codes should be changed in light of the findings from this study and the Ecotope study should be conducted.

Address/Support Research On Fragmented, Serial, And "Value Engineering" Aspects Of The Building Design Process. As documented throughout this study and other studies listed in Section 2, fragmentation and serial sequencing of the building design process combined with "value engineering" often spell disaster for advanced lighting design and implementation Researchers at Washington State

[2] *Baseline Characteristics of the Nonresidential Sector in Idaho, Montana, Oregon and Washington,* D. Baylon et al, prepared by EcoTope for the Northwest Energy Efficiency Alliance, Draft, March 2000

University are focusing on in-depth observation and analysis of the relationships between market actors involved in the building design process that may illuminate improved understanding of both the contractual and social basis for how decisions are made and "unmade" during this process.[3]. Although, perhaps too broad and exploratory an area to sponsor on its own currently, the Alliance may want to contribute to this research effort as it matures and yields benefits.

Facilitate Program Cooperation And Manufacturer Outreach. A brief review of PNW utility websites indicates that there are a number of lighting and new construction programs in place throughout the region. If the Alliance has not already, it should compile all of the PNW utility program information that affects C&I lighting. Through this compilation, a picture of the region's utility C&I lighting programs can be developed which would then facilitate an analysis of regional consistencies, inconsistencies, and gaps. Additional research could yield an assessment of which utility programs are working well (i.e., resulting in the installation of good quality, energy efficient lighting systems). These efforts would provide important further context for the Alliance in making its next round of decisions about which, if any, regional lighting initiatives to develop.

In addition, the Alliance may also want to consider taking a national leadership role in developing or supporting inter-regional lighting initiatives, as there appears to be a growing need for national coordination.

[3] The first phase of this research was documented in Lutzenhiser, Loren and Rick Kunkle, New Commercial Buildings Market Transformation Research Needs: A Scoping Report Prepared for the California Institute for Energy Efficiency, Washington State University, September, 1998. The second phase, which will include results from observance of actual design processes, is currently in progress.

1 INTRODUCTION

This report presents the results of a comprehensive market research study (the Study) focused on the commercial and industrial (C&I) lighting industry of the Pacific Northwest (PNW). In Spring 2000, the Northwest Energy Efficiency Alliance (the Alliance) contracted with XENERGY Inc., with assistance from Rising Sun Enterprises Inc., Pacific Energy Associates, and Energy Market Innovations, to conduct the Study presented herein. Primary research for this Study was conducted from May through July 2000. The Alliance is currently planning to use the information and recommendations presented in this report to decide whether to develop a set of initiatives tailored to the unique needs of the region's C&I lighting market. The research presented in this report is intended by the Alliance to be a *first-step effort* from which additional market research may follow.

1.1 ALLIANCE OBJECTIVES AND KEY RESEARCH QUESTIONS

In conceiving this Study, the Alliance had three overarching and closely intertwined objectives:

1. Characterize the current market for C&I lighting products and services in the PNW,
2. Assess the merits of lighting technologies and practices that go beyond current standard practices; and
3. Provide suggestions for new Alliance initiatives in the C&I lighting market.

With respect to the first objective, market characterization, the Alliance had a number of specific questions about the current market in the PNW, among these were the following:

- What are the key dimensions along which the current C&I lighting market is segmented and what segmentation approach or approaches should the Alliance use in developing its initiatives?
- How are key decisions made in the C&I lighting market among end users and supply-side actors? How do these decisions vary with respect to the key market segments, market events, and high-efficiency lighting opportunities (e.g., commercial versus industrial, smaller tenant improvements versus large new construction, efficient components versus integrated lighting design and daylighting, planned versus last minute changes in equipment installed, etc.)?
- What do the current and recently past markets for C&I lighting products and services in the PNW look like in terms of product flows among market actors, stocking and specification practices, and actual sales? (Products of special interest are electronic ballasts, dimming electronic ballasts, T-5 fluorescent lamps, high efficiency T-5 fixtures, dimming controls, occupancy sensors, compact fluorescent lamps and fixtures - especially of high bay areas, etc.)
- Where are the key leverage points, and motivators for change among each market actor group?

Underlying the second key objective, assessing new C&I lighting opportunities, was the desire to develop answers to the following key questions:

- What are the most promising new technologies and practices and what are the merits, limitations, and market barriers currently associated with each?
- What is the relative potential of these new technologies and practices among the different end-user segments?
- What non-energy benefits, if any, do the new technologies and practices offer?

The third key Alliance objective was to assess and develop new initiatives that are likely to lead to sustainable changes in the PNW market for high-efficiency lighting technologies and design practices. Key specific Alliance questions related to this objective were:

- What C&I lighting initiatives are currently being implemented by other efficiency organizations around the country?
- What could be adapted from other lighting and controls projects in the region or nationally? Should the Alliance partner with other programs being implemented elsewhere?
- Are there any gaps among these existing initiatives and, if so, how important are these gaps and what initiatives are needed to fill them?
- How would or should new Alliance lighting initiatives relate to other Alliance programs?
- How should new Alliance initiatives address the needs of the key players/audiences/ stakeholders and among what commercial and industrial segments would prospective initiatives have the greatest likelihood of success?

1.2 OVERVIEW OF STUDY SCOPE

Like any study, the current effort required some prioritization among the Study objectives and research questions given the resources allocated and project schedule. The effort was intended to be a relatively fast-paced effort that combined primary research, secondary sources, and the knowledge of industry experts to produce a product that would be the key first step in the Alliance's new C&I initiative development process.

Among the three objectives presented in Section 1.1, the bulk of the project resources were allocated to the first one, developing a market characterization specific to the Pacific Northwest. This market characterization was developed principally from over 120 in-depth interviews we conducted with supply-side market actors in the PNW.

The second key objective, assessing new C&I lighting opportunities, was addressed through use of lighting experts on our project team and their use of secondary sources. This effort represented about 20 percent of the project resources and resulted in the products presented in Section 6 - Promising Technologies and Practices and several of the appendixes. Readers should bear in mind that our principal objective was to summarize the key opportunities and issues associated with them, not to develop or present detailed technical descriptions of these opportunities. As we indicate in Section 2, there are a number of sources available that provide more details on the technologies and practices summarized in this Study.

The last key objective, to assess and develop new initiatives, was tackled through a combination of summarizing initiatives currently being implemented or considered by organizations other than the Alliance and the conducting of structured brainstorming sessions with our project team members and with a broader community of lighting researchers and program designers. It should be noted that this Study was intended to provide only an initial step toward development of new Alliance initiatives for the C&I lighting market; thus, we do not attempt to "pick" the best initiatives or to provide detailed prospective initiative specifications. Rather, we provide a general discussion of market initiatives that we recommend the Alliance consider further in Section 7. In addition, the Alliance itself will use the information in this Study to further develop and assess prospective new initiatives through in-house program development processes, a competitive bidding process that will likely include both general and targeted request for proposals for C&I lighting initiatives, and further market research.

1.3 ORGANIZATION OF REPORT

The remainder of this report is organized into two volumes. Volume I provides the main report and appendices. Volume II provides some additional technical documentation of the technologies and practices discussed in Section 6 and is intended primarily for Alliance staff. Volume I is organized as follows:

- Section 2 provides a summary of the approach used for the study and a list of key secondary sources utilized.
- Section 3 presents an overview of relevant building and lighting industry market structures that form an important backdrop to the primary research conducted and resulting recommendations.
- Section 4 summarizes the characteristics of the target populations and primary research samples completed.
- Section 5 discusses the results of interviews with key market actors. These results provide a comprehensive baseline assessment of the current market for commercial and industrial lighting technologies and practices in the Pacific Northwest.
- Section 6 contains our discussion of promising technologies and practices and provides an assessment of the total region-wide potential associated with these opportunities.
- Section 7 presents our discussion of initiatives for the Alliance to consider to further increase the penetration of high-efficiency lighting technologies and practices in the Pacific Northwest.
- Appendix A provides a summary of an informal session on nonresidential lighting initiatives conducted at the American Council for an Energy-Efficient Economy's Summer Study 2000.
- Appendix B consists of detailed results from our market actor surveys.

- Appendix C provides the survey instruments used for the market actor interviews.

2 STUDY APPROACH

In this section, we discuss the research activities conducted to support each of the key Study objectives. As introduced in Section 1, the key research activities included the following:

- primary research consisting of in-depth interviews with regional market actors and lighting experts;
- secondary research consisting of detailed review of lighting studies relevant to the Study objectives;
- utilization of the knowledge of our project team's lighting experts; and
- analysis of current non-Alliance initiatives and structured brainstorming of prospective new initiative needs.

2.1 PRIMARY RESEARCH IN THE PNW

Although the original plan for this Study called for a combination of secondary research to be complemented with modest levels of primary research in the PNW, in our proposal to conduct the Study we suggested a shifted emphasis that would lead with primary research and complement with secondary sources. We did this for a number of reasons. First, the Alliance had a number of specific research questions for which no answers existed for the PNW region. Second, the Alliance was specifically interested in knowing the extent to which the key subregions of the PNW differed from one another (i.e., east and west of the Cascades). Third, the Alliance was poised to embark on a process of developing and implementing new lighting initiatives relatively quickly on the heels of this Study. Although we were fairly confident that the C&I lighting market in the PNW would turn out to be fairly similar to other C&I markets analyzed in recent studies outside the region, we believed that the combination of the three factors above warranted an approach that would provide more than anecdotal region-specific results. We also believed that our experience, and the experiences of others, in conducting similar C&I market studies in other regions could be leveraged to cost-effectively answer most of the Alliance's market characterization-related questions through primary rather than secondary research.

Because the scope and schedule of the project did not allow for all market actors to be interviewed, a decision was made to focus the primary research activities in this Study on the supply-side of the market; therefore, no end-user surveys were conducted. Given the Alliance's stage in the initiative development process, supply-side interviews were chosen as the key primary research effort because we believed that these market actors would provide more information of value than end-user interviews. In addition, the Alliance had recently completed a study of regional commercial new construction practices (see Table 2-2 for citation) that included detailed on-site surveys and general decision-maker interviews that provided excellent data on the penetration of lighting technologies and controls. A summary of the market actor interviews conducted and their rationale is provided in Table 2-1.

Table 2-1
Primary Research Conducted for this Study

Market Actor Survey	Number	Rationale for Inclusion
Designers (In-depth) Electrical Engineers Architects Lighting Designers	30	Necessary to identify design and product-related trends unique to the PNW (and perceptions vis-à-vis non-energy benefits). Critical to assessing acceptance of new opportunities in PNW. Helpful with respect to market Segmentation as double-check on secondary sources. Useful to corroborate quantitative data obtained from distributors and contractors.
Electrical/Lighting Distributors	60	Necessary to develop PNW-specific stocking and sales data market Characterization and product flows. Critical to develop backcast of historical trends. Helpful for assessing acceptance of new opportunities in PNW.
Electrical/Lighting Contractors	30	Provide critical information needed to assess extent of contractors' influence on design and specification. Improve our understanding of the rationale for last-minute equipment re-specification. Necessary to assess contractors purchase and sales patterns. Critical to assess contractors' perceptions of and experiences with installation of daylighting and controls.
Other (In-depth) Alliance staff Utility program managers Regional/national program managers, industry experts, Manufacturers	15	Fully understand Alliance members' needs. Ensure Study activities leverage available sources. Characterize existing and near-future program initiatives in and out of region. Ensure inclusion of latest non-energy benefits information.

Additional details on the characteristics of the samples achieved and populations estimated are provided in Section 4 - PNW Population and Sample Characteristics.

In addition to the primary market actor interviews, interviews were conducted with a number of regional C&I lighting industry experts. The purpose of these interviews was to ensure that we took advantage of the existing knowledge base in the PNW to inform our understanding of the region's lighting markets. To aid in this effort, and to ensure we had input from all regions of the Alliance, an e-mail request for contacts was sent to the Alliance Board members whose service territories include the eastern portion of the region. Interviews were conducted with a number of staff at the Seattle Lighting Design Lab, members of its Technical Advisory Committee (TAC), as well as PNW energy consultants and lighting initiative leaders outside the PNW.

2.2 Secondary Research

Information integrated into this Study was obtained from a wide variety of secondary sources. These studies were used to further develop our characterization of the market, identify gaps in the existing information, and inform our primary data collection activities (principally, our survey instruments). The sources generally fell into four general categories:

a) market characterization and baseline studies,

b) assessments of technology and practice opportunities,

c) summaries of lighting programs and initiatives, and

d) manufacturer product literature.

An annotated summary of the key sources utilized is provided in Table 2-2 and Table 2-3.

2.3 Expert Knowledge

To complement the primary research obtained directly from market actors in the Northwest and our review of secondary sources, we included on our study team two experts in nonresidential lighting design, technologies, and practices (Robert Sardinsky of Rising Sun Enterprises and James Benya of Benya Lighting Design). Inclusion of lighting experts who are at the leading edge of energy-efficient lighting design was important to the technology/practice characterization part of the study. In addition, Michael Siminovitch provided technical review of the technology and practice characterizations in Section 6. We also interviewed several lighting experts at the Seattle Lighting Laboratory and at the Lawrence Berkeley National Laboratory.

2.4 Structured Brainstorming

Two types of structured brainstorming were utilized during this project to generate ideas for the initiative considerations presented in Section 7. First, an internal brainstorming session was held among the project team members which focused on generating ideas resulting from our primary research results and technology and practice characterizations. This session was held in mid-August 2000. Second, we co-led an informal session at the American Council for an Energy-Efficient Economy's Summer Study in late August 2000. This second session included lighting experts (including a leading ballast manufacturer) and initiative leaders from throughout the country. In this session, we focused participants on trying to identify "gaps" among the combined efforts of lighting program implementers nationally. The session was well-attended and very productive. A summary of the results of this session is provided in Appendix A of this report. The results of both brainstorming sessions provided the bulk of the ideas on initiatives the Alliance should consider, which are presented in Section 7 of this report.

Table 2-2
List of Sources for Market Characterization

Secondary Source on the Market	Topics
Advanced Lighting Guidelines, 2000 (near draft release)	Overview of all major lighting equipment groups, their applications and design issues. Research is presented on human vision, daylighting, productivity, health and safety.
Baseline Characteristics of the Nonresidential Sector in Idaho, Montana, Oregon and Washington, D. Baylon et al, Ecotope, March 2000.	Study of current building practices and attitudes in the Pacific NW providing baseline information to be used in designing market transformation programs and evaluating their success.
PG&E/SDG&E Commercial Lighting Market Effects Study, prepared by XENERGY Inc. for the California Demand-Side Management Advisory Committee, July 1998.	Documents T8 lamp and electronic ballast market effects attributable to utility efficiency programs over the period 1992 to 1997. Also provides a broad market characterization of all aspects of the commercial lighting industry including manufacturers, distributors, designers, contractors, ESCOs, and end users.
Baseline Study for Assessing Daylighting Design Tools, prepared by TecMRKT Works for Pacific Gas and Electric Company, June 1999.	A comprehensive market assessment of the lighting design process, barriers to daylighting, and the potential of new daylighting tools to reduce these barriers.
Vision 2020: The Lighting Technology Roadmap, IES, IALD, et al, August 20, 1999.	A strategic plan for identifying and moving toward ideal lighting in buildings over a twenty year period. Discussion of market barriers to increased use of high efficiency technologies and good design practices and possible intervention activities.
Skylighting and Retail Sales: An Investigation into the Relationship Between Daylighting and Human Performance, Heschong Mahone Group, August 20, 1999.	Case study of 108 nearly identical chain stores on the effect of daylighting with skylights on retail sales. Skylit stores were found to average 40% higher sales after other variables were controlled.
Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance, Heschong Mahone Group, August 20, 1999.	Similar to the above, this study provides compelling quantitative evidence demonstrating the benefits of daylighting in improving children's learning and performance.
Lighting Quality - Key Customer Values and Decision Process, prepared by Ducker Research for the Light Right Consortium, August, 1999.	Assessment of most important concerns of end user decision makers about the built environment. Demonstrated that lighting was "on the radar screen" but that links to productivity and occupant satisfaction were critical to capturing attention and investment.
Lighting Design Lab Market Assessment, J. Reed, A. Oh, N. Hall, TecMRKT Works, April 1999.	Description of the current lighting design practices in the Pacific NW, the programs of the Design Lab, and the influence of the Lab's programs on current practice.
California Nonresidential New Construction Baseline Study, RLW Analytics Inc., July 1999.	Market characterization of current design and building practices and the attitudes and motivations of all actors. Quantitative surveys of architects and engineers were implemented via the Internet, and models were built to measure energy savings of particular sites.

Table 2-2 continued
List of Sources for Market Characterization

Secondary Source on the Market	Topics
Lighting Market Sourcebook, D. Vorsatz, et al, LBNL, December 1997.	Identifies domestic consumption of lighting products by end-use sector and the distribution channels used. Historical data for ballasts and lamp shipments are also presented. Some discussion of market barriers and interventions.
The U.S. Lighting Fixtures Industry, An Economic & Market Study 1998 Edition, Economic Industry Reports, Inc.	Description of domestic lighting fixture production by major industry category (e.g., outdoor/indoor, residential/nonresidential). Specific lamp and ballast technologies are not identified beyond "incandescent" "4-ft fluorescent" "HID" and the like.

Table 2-3
List of Sources for Emerging Technologies and Practices

Secondary Source - Emerging Techs and Practices	Topics
New High-Intensity Fluorescent Lights Outshine Their HID Competitors, J. Rogers and I. Krepchin, E-Source Tech Update, January 2000.	Discusses advantages of high-output T-5 and other fluorescent technologies over HID lamps for high-bay applications. The fluorescent lamps have better color rendition and stability, less lumen depreciation, better dimming options, instant start and less glare.
Competing Technologies Vie for Eight-Foot Fluorescent Fixture Market: Evaluating the Alternatives, R. Sardinsky and B. Heckendorn, E-Source Tech Update, March 1999.	Discusses the alternatives available to facility staff when replacing old style 8-ft fluorescent fixtures. Ballast factor improvements, rare-earth phosphor selection, reflectors, and ballast/lamp combinations are all discussed in detail.
Product literature from Electronic Lighting, Inc.	Addressable ballast systems are described in which it is possible to redefine which fixtures are controlled by a particular switch from a central computer without rewiring. Behavior, such as stepping or dimming may also be controlled.
New Dimming Controls: Taking It Personally, I. Krepchin and J. Stein, E-Source Tech Update, March 2000.	Personal dimming controls for space and task lighting in the workplace are the subject of this research. The equipment such as ballasts, switches, sensors and the like are all presented along with the design knowledge necessary to create a successful project. The benefits of personal control over light levels are quantified.
Lighting Technology Atlas, E-Source, 1997.	Fairly comprehensive look at energy efficiency opportunities in the lighting industry. Special attention is given to new technologies and practices.
Product literature from Hewlett Packard.	Discusses state of the technology for white light LED lamps. Concludes that applications are currently limited to harsh climate, artistic, emergency, and confined spaces, but should expand soon.

3 RELEVANT MARKET STRUCTURES

3.1 BASIC BUILDING AND LIGHTING INDUSTRY MARKET STRUCTURES

The energy used to light buildings is significantly affected by the choices made during the design and construction of buildings, and lighting systems are an integral subcomponent of this process. To understand how lighting systems are designed and specified, it is important to understand the nature of the relationships among the many market actors involved in the building design and construction process.

This section presents a brief overview of building design and construction within which various market actors are designing, selling, specifying, and installing lighting systems. The common contractual relationships made during the construction of a new building or as part of a major retrofit are presented first. These relationships frequently determine how information moves between parties and how decisions are made that affect the quality, cost, and efficiency of lighting. Next, the typical practices and motivations of the professionals are described. Finally, existing barriers to advanced, high-efficiency lighting are discussed.

3.1.1 Contractual Relationships Affecting Lighting

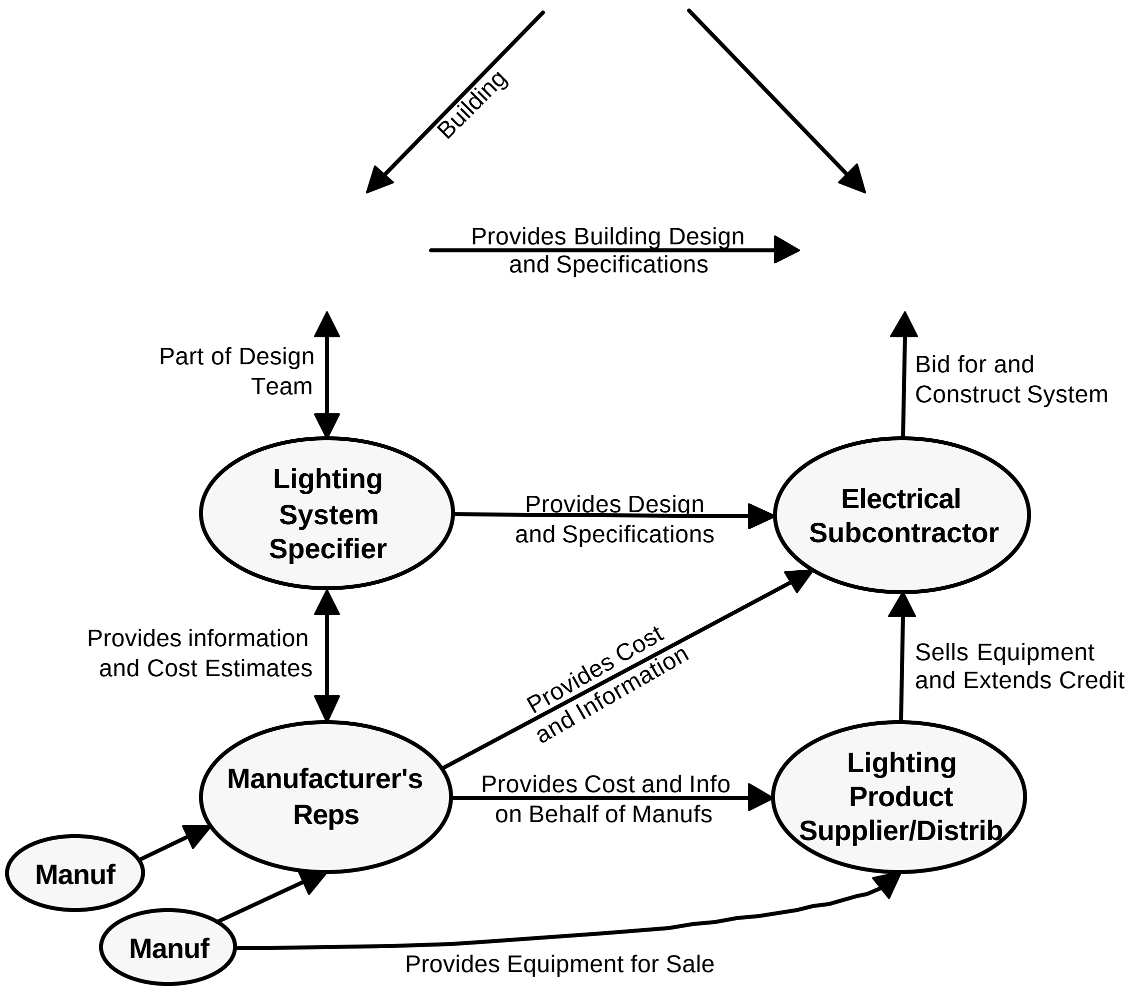
A summary of the common contractual relationships during the design and construction process is provided below, along with the impact of the arrangement on lighting choices. The material presented in this section is generalized and we recognize there are exceptions. More than trying to set out basic principles of contracting, we are trying to highlight typical problems with the various contract models. For example, when we say under the design-build (DB) contractual model that adherence to the project schedule is emphasized over integrating the work of the HVAC, lighting, and architectural designers, it should be understood that this is not always the case, only that it is a common practice.

Graphic Overview of Market Actor Roles

We begin with a graphic overview of the general relationships between the key market actors involved in the design and delivery of lighting systems. Figure 3-1, provides an overview of the activities and interactions of the various market actors (the roles of these actors are discussed in Section 3.1.3). Some of the key contractual issues underlying the traditional approach that will be discussed further in this section include the following:

- Most contracts are awarded based on the lowest bid that still meets certain minimum qualifications. This inevitably leads to cost-cutting later and guarantees mediocre results. A low bid also does not usually include enough budget for time to assess design options after feedback is obtained.

Figure 3-1
Traditional Design and Delivery Process
Reprinted from Vision 2020, The Lighting Technology Roadmap, March 2000.



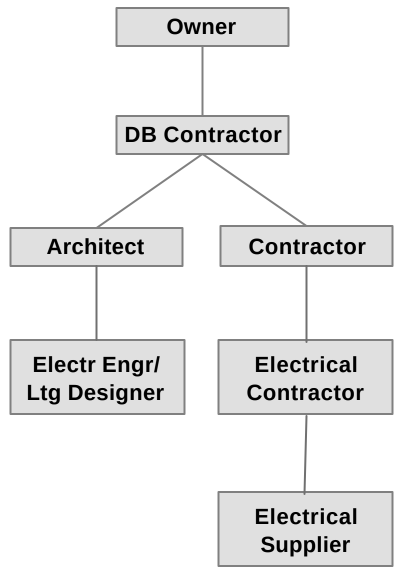
- The existing incentives act against holistic design by rewarding speed, not quality. Contracts generally include a checklist of requirements that provide no incentive for doing better.
- Communication is largely limited to those parties who share contractual obligations. Without a forum for regular communication between non-contracted parties, it is unlikely that an integrated lighting system will be possible.

Design-Build Contractual Model

Under this model, shown in Figure 3-2, the owner contracts with a DB contracting firm for all design and construction services. The DB contractor is then responsible for hiring and managing architects, electrical and mechanical engineers, contractors, and advisors as needed.

Advantages: By creating a single point of contact for the owner, major project decisions are made more quickly. The DB model is frequently chosen on "fast-track" jobs.

Figure 3-2
Design-Build Market Actor Relationships



Key Issues: The DB contractor has no incentive to take budget or schedule risks with innovative lighting designs. If there is an incentive at all, it is usually for early project completion rather than high-quality lighting or low operating costs. DB contractors bid on the up-front cost of construction, so design options that save energy and money over the long term are usually ignored.

This model functions well if the owner makes a clear contractual statement requiring specific performance targets for the lighting system. This puts the owner in the position of needing to have some lighting expertise in order to clearly specify energy efficiency and quality requirements. Some efforts are being made to identify simple scoring systems that would help owners and others in this process (see, for example, the forthcoming study by NYSERDA and ICF Consulting on *High Quality Efficient Lighting for Small Commercial Spaces*). Also, a new form of DB construction is emerging with a strong focus on maintenance. The firms specializing in this new approach call themselves "design-build-maintain" firms, and have a commitment to the long-term operation of the buildings, making this model much more attractive from an energy efficiency standpoint.

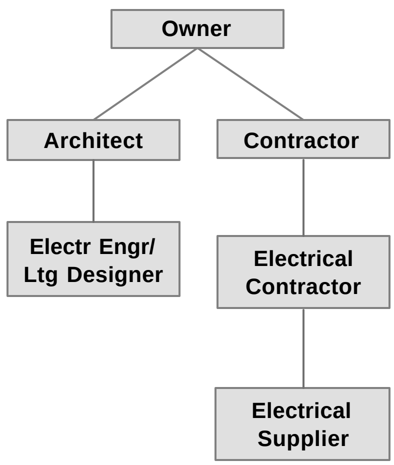
Key Leverage Points: Owner during bid and contract negotiation, DB contractor during final design process, architects and electrical engineers during detailed specification process, contractors during installation, distributors during ordering.

Plan/Specify Contractual Model

With this model, shown in Figure 3-3, the owner contracts with an architectural or architectural/engineering (A/E) firm for all design services. The architect is then responsible for hiring and managing electrical and mechanical engineers and advisors as needed. A second contract is made between the owner and the prime contractor for all construction services.

Advantages: Some advantages are gained regarding oversight of construction by separating the design and construction roles. The A/E firm may be willing to call attention to construction errors that a DB contractor might choose to ignore.

Figure 3-3
Plan/Specify Market Actor Relationships



Key Issues: The architect's direct financial motivation is usually to build an expensive building rather than an effective or efficient one. This is due to the standard practice of negotiating fees based on a fixed percentage of the total project budget. Of course, good architects recognize the long-term value of providing a high-quality building. Nevertheless, there is almost never an explicit incentive for the architect to provide the tenants with a building with low operating cost or high-quality lighting. The notable and rare exception to this is a building energy performance contract, in which the owner makes a contract with the design team, making a portion of the fee dependent on the measured energy use of the occupied building.[4] Effects from weather and the level of occupancy are screened out using a computer simulation. In Figure 3-4, we provide an example of a simple incentive scheme for calculating

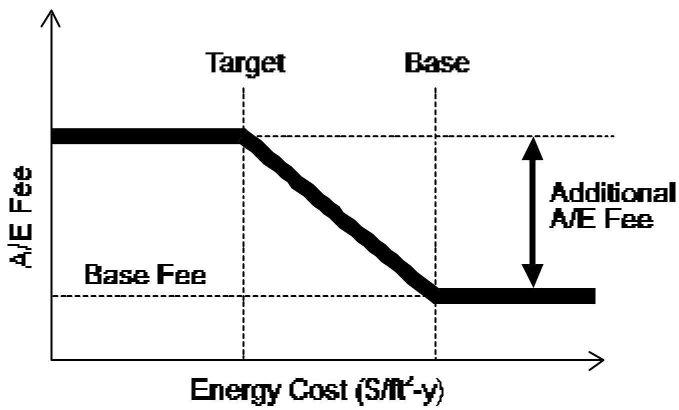
[4] We describe this performance contracting approach under the plan/specify model because it is more likely to occur under this model than under the design-build model. However, it can in theory occur under either. There are a number of issues associated with performance contracting for new buildings, however, which have limited the penetration of this approach. See, for example: Eley, Charles, and Geof Syphers, *Performance Contracting for New Construction - Insuring Value from Your Investment*, Miami AIA Conference Proceedings, 1997; and Stein, Jeff R. and Aditi Raychoudhury, *The Jury is (Halfway) In: New Building Performance Contracting Results*, ACEEE vol. 4, 2000.

such a performance payment, which includes a base level performance (usually set to minimally comply with code) and a target level of performance. The performance incentive increases with decreasing energy cost and may have a cap on the maximum incentive. A penalty is possible for buildings that do not meet the base level.

The plan/specify model functions well if the architect has a strong commitment to good lighting or if specific lighting system performance targets are set such as mentioned in the DB model.

Key Leverage Points: Owner during bid and contract negotiation, Architect during design final design process, electrical engineers during detailed specification process, contractors during installation, distributors during ordering.

Figure 3-4
Example of Performance-Based Fee (Which Are Rarely Used)



Nascent Collaborative Process Model

According to recent research summarized in Reed, et al., 2000,[5] there are building professionals who are significantly concerned about the quality and performance of buildings that has resulted from the devolution of the traditional architectural model and the shortcomings of the DB model. These building professionals are promoting what they call a "collaborative process model" to improve integration and quality. This model stresses the importance of close attention to the organization, management, and interaction among members of the team as an integral part of the design process. This emerging model currently accounts for a small share of new buildings. Those supporting and practicing the collaborative process model may be potential allies for efforts to improve building energy efficiency. The progress of this model should be watched.[6]

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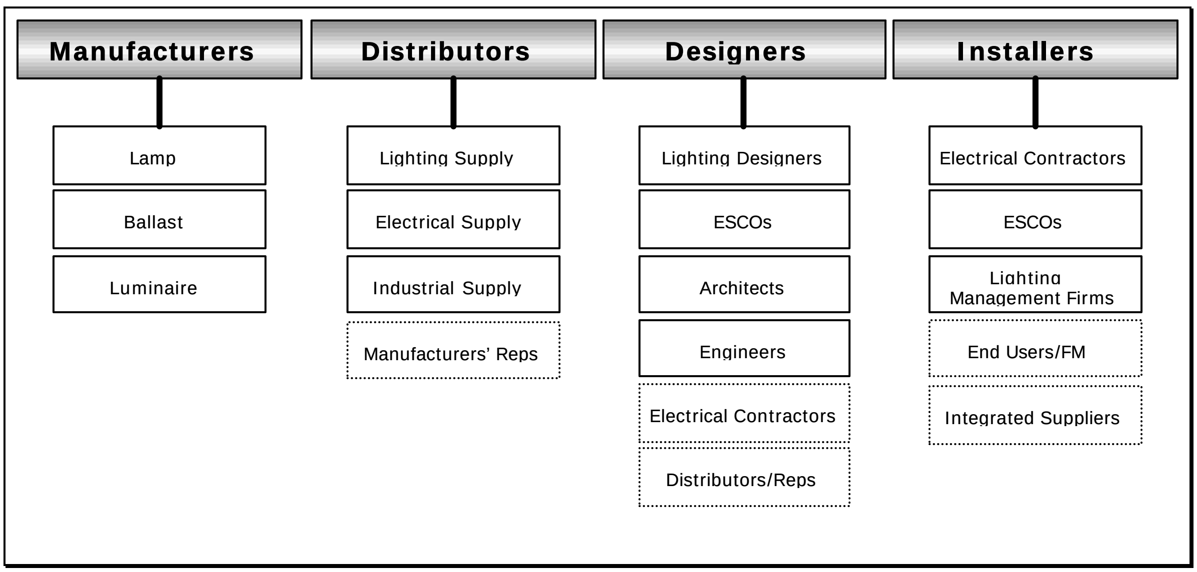
[5] Reed, John, Andrew Oh, and Nicholas Hall, "The Structure and Operation of the Commercial Building Market," American Council for an Energy-Efficient Economy Summer Study 2000, August. Volume 4, pp. 267-282.

[6] The Collaborative Process Institute of Los Gatos may be a useful source of information on this trend and can be contacted at 408-353-6677.

3.1.2 Lighting Market Supply-Side Segmentation

To understand the structure of the supply side of the commercial and industrial (C&I) lighting market, it is important to identify and understand the motivations and disposition of its component parts. Using a supply-side analysis we developed for previous work, we divide the market into 4 primary segments, 13 subsegments, and 5 quasi-subsegments that do not clearly fall under the primary segments. Figure 3-5 summarizes the segmentation used in our analysis.

Figure 3-5
Supply-Side Lighting Segmentation Scheme*



*The solid boxes represent discrete subsegments that fall under the primary segment identified in the shaded box above it. The broken boxes represent quasi-segments that do not clearly fall under any one segment. For example, electrical contractors and distributor/reps sometimes make last-minute decisions contrary to the design intent. "FM" = Facility Management firms.

Although this discrete segmentation of the supply-side market is generally appropriate and useful, it is also important to recognize that many supply-side lighting firms engage in multiple levels of the supply chain. Different segments will be more or less important, depending on the particular aspect of high-efficiency lighting being promoted (e.g., efficient components versus increased use of daylighting).

3.1.3 Practices and Motivations of the Professionals

Contracts are not the only factor that shape the kinds of decisions made in C&I lighting. Indeed, professionals look at projects very differently and often define a successful project in completely different terms. In a 1992 Strategic Issues Paper, E-Source presented what they called the *Tower of Babel*, a list of the metrics used by the various actors involved in the design, construction, operation, and occupancy of buildings to gauge their success. Table 3-1 shows the actors relevant to the lighting field and the metrics they look to most.

Because of these differences in measuring success, conflicts among market actors can easily occur. For example, a daylighting design that requires a lightwell into a six-story building will pit developers—who value low cost per square foot—against lighting engineers—who value footcandles and light quality but cannot exceed energy codes. This type of conflict can occur for a component as small as an occupancy sensor, for example. The initial commissioning of these devices is rarely sufficient to ensure proper long-term functioning and requires interaction between multiple market actors whose objectives may be in conflict.

Table 3-1
The Different Metrics for Defining Success

Specialist	Performance Metric
Developers	Dollars per square foot
Electrical engineers	Watts per square foot; code compliance
Lighting engineers	Footcandles; quality of light
Construction managers	Critical path and specifications/adherence to drawings
Contractors	Budget and schedule (no callbacks)
Suppliers	Sales and margins
Construction workers	Signoff
Leasing agents	Quick rental; dollar per square foot
Building operators	Simple payback
Maintenance staff	Complaints
Occupants	Comfort
Utility DSM staff	Dollars per avoided kilowatt and kilowatt-hour

*Adapted from *Energy Efficient Buildings: Institutional Barriers and Opportunities* by E-Source, Inc., 1992.

In the following subsections, we discuss the basic roles and motivations of each of the key supply-side market actors involved in lighting design and implementation.

Architects

Architects are generally responsible for the overall building "product" in new construction. They hire mechanical and electrical engineers to design the HVAC and electrical systems (including lighting) or contract with firms that do this work. Architects design the building shell, choose materials and finishes, and place and size fenestration.

Payment is usually by lump sum or by hours worked with an upset limit. Despite this, the negotiated price is almost always based on a percentage of the total project cost.

Motivations include:

- **Creative Expression**. Architects tend to be artistic people who enjoy the process of creating. They desire to leave a lasting impression in their artwork.

- **Pride**. Architects usually want an attractive building to enhance their portfolio. They have a sense of pride in their work since the physical building they design is seen and judged on a daily basis.
- **Profit**. Architects often want to push the overall project budget up to increase their fee. On fixed priced jobs, they are motivated to spend as little time as possible to maximize profit, while maintaining guaranteed quality.

While some architects provide lighting design themselves, about three quarters of those interviewed in this study do not. The majority hires electrical engineering firms for their lighting design and specification work.

Electrical Engineers

Electrical engineers design most of the lighting throughout the Pacific Northwest. They either work for an A/E firm, or more likely, work for an electrical engineering firm hired by the architect for lighting and wiring plans.

Payment is usually fixed price, negotiated as a percentage of the design budget.

Motivations include:

- **Time**. Engineers want a "call-back-proof" design. They are motivated to design the lighting system using materials and techniques familiar to the contractors to reduce callbacks or changes.
- **Pleasing the Architect.** Electrical engineers are often concerned with pleasing architects, since these are their principal clients on lighting jobs.
- **Profit**. Electrical engineers want to spend as little time as possible on fixed-price jobs to maximize profits. This contributes to the use of rule-of-thumb and templates for lighting design discussed later in Section 5.

Electrical engineers tend to use manufacturer literature and contacts as well as web sites, trade shows, and magazines to keep up with the latest technologies.

Distributors

The primary role of the distributor in the lighting value chain is to stock and sell lighting equipment to contractors and end users. Besides being equipment order fillers, however, distributors often get involved in some aspect of the design process, particularly for small jobs. This may be related to the fact that contractors are often awarded work based on the lowest bid. Distributors sometimes provide basic design services to their contractor clients to provide extra value on what is otherwise a commodity purchase. As discussed in Section 5 and presented in Appendix B, 83 percent of the distributors surveyed in this study offer lighting design and fixture layout services. Sixty-one percent offer equipment specification services, although all will supply detailed equipment recommendations written in a format that can be used for specifications. In addition, distributors reported specifying 35 percent of all the equipment they sell.

Distributors report bidding on jobs in three-quarters of cases. As a result, margins are thin and wholesale prices have very little variation across providers. Payment is primarily through equipment sales. Rarely are design and specification services paid. Distributors sometimes provide equipment financing for the contractors, carrying the equipment costs through to the next construction payment.

Motivations include:

- **Sales Competition**. Distributors are competitive salesmen, and desire to outperform other distributors.
- **Education**. Some distributors view their role as educators, introducing designers to new equipment and correcting problems in designs.
- **Profit**. Because of the sales-orientation to their business, employees at some distributorships are paid on commission.

Distributors rely on manufacturers, trade magazines and shows to keep them current on new technologies.

Electrical Contractors

Electrical contractors are mostly small businesses, with between 1 and 10 people running the entire operation. Among the sample that qualified for our interviews (based on a threshold of at least $50,000 of C&I lighting work per year), contractors reported that C&I lighting accounts for about 40 percent of their business.

Contractors are an important part of the C&I lighting market because of their role in installing fixtures, wiring, and controls. Final installation and fulfillment of design intent is ultimately in their hands. Contractors report that they have a fair amount of flexibility when it comes to the installation process. *Contractors reported that they are permitted to substitute equipment on half their jobs.* As noted later in Section 5 of this report, they do so primarily because the replacement equipment is cheaper than the equipment specified or because the specified equipment is unavailable. These substitutions may significantly impact the type of lighting equipment that ends up in buildings. This finding underlines the need to compare actual equipment sales or installations with original specifications to assess whether these last-minute substitutions systematically impact the energy efficiency of lighting systems.

Payment is generally fixed price, negotiated as a percentage of the total "hard cost" construction budget (i.e., not including any of the design work, permits, land cost, financing, etc.).

Motivations include:

- **No Callbacks.** Contractors are loath to return to a job site when it is not part of the required commissioning. The cost of return visits can quickly sap any profits.
- **Profit**. Fixed-price contracts encourage the use of low first-cost lighting. Substitutions, sometimes done in the name of 'value engineering,' can increase profits in a tightly competitive market. Further motivation toward profit involves spending as little time as possible on site.

Value Engineering

At its most generic level, value engineering is the practice of analyzing function and value from an economic perspective. In practice, value engineers in the construction business look for more effective construction methods, cheaper material alternatives, and reduction of waste—both of materials and time, particularly with the intent of reducing overall costs. The value engineer tends to look across the individual specialty areas in search of savings. The term 'value engineering' is generally associated with a specialized firm or individual who takes on the position of value engineer in the process, however, individual market actors sometimes take on the role themselves or reference the term as a justification for actions that are taken in pursuit of cost reductions, especially late in the construction process.

Despite the benefits to the building industry, value engineering has been widely criticized for ignoring or reducing benefits that are inversely related to first cost, such as some energy-efficient HVAC and lighting equipment and designs. This perception evolved from numerous examples of last-minute substitutions and misinterpretations of design intent. To address this issue, it is important to understand the motivations of those operating under the rubric of value engineering. Table 3-2 provides examples of how value engineering can be problematic.

3.2 High Level Concerns Related to Improving Lighting Practice

Despite success throughout the 1990s of increasing the penetration of T8 lamps, electronic ballasts, as well as compact fluorescent lamps and fixtures, there are a number of significant issues facing any efforts to further lighting design and lighting quality required to achieve savings below today's current practices. Six high-level barriers to further improvements are presented here. These barriers are explored further in Sections 5, 6, and 7.

3.2.1 Lack of Integration

There are two issues pervading the lack of professional integration in commercial and industrial lighting: the linear nature of most design work and the degree of specialization.

Table 3-2
Motivations of Problematic Value Engineering

Pre-bid	Decisionmaker:	Contractor
	Motivation:	Lower bid price to win a job
	Details:	Contractors make equipment substitutions to save money since they nearly always get work based on having a low bid price. Most substitutions are not last-minute, but are planned as part of the contractor's bid before the project is awarded. These substitutions are usually reviewed by the architect or DB project manager for suitability. With these pre-bid substitutions, a percentage of the savings is reflected in the project bid, and a percentage is pocketed by the contractor.
Cut corners	Decisionmaker:	Contractor
	Motivation:	Increase contractor profit
	Details:	Once a project is awarded to a contractor, there is a further incentive to cut costs on materials and labor. On jobs of all sizes, but especially on complex jobs, the contractor may cut costs below his actual bid to increase his profit since his payment is fixed at the contract price. Cutting costs is achieved by using lower cost labor, less expensive and less labor-intensive equipment, and simplifying the design.
Value	Decisionmaker:	Third-Party Value Engineer
	Motivation:	Reduce overall project construction costs
	Details:	If a project begins to run over budget, last-minute equipment substitutions and design simplifications are often made by a value engineer. The value engineer is frequently a third party brought in to identify areas where savings are possible. The intent behind value engineering is to take the time to identify savings opportunities in equipment and labor that are missed by the specialists on the job (e.g., architect, electrical engineer, contractor). On very large jobs, value engineers are often brought in to identify savings during and shortly after architectural programming. The problem arises when long-term operating savings are traded away for immediate construction cost savings.

Linear Design

Lighting designs that make use of natural light are often stifled by the traditional linear approach to design. Most significant architectural designs are completed before the electrical engineer or lighting designer is brought into the design process, seriously reducing the opportunities for including daylighting provisions in the building shell plan. Consequentially, integration from all levels of the design team rarely occurs. Furthermore, if real synergy is desired, the mechanical engineer must also participate at the early stages to provide input on actions that affect heating and cooling loads. If designers are not well informed, then changes to the building shell to accomplish daylighting can dramatically affect these loads. Without input from the mechanical engineer during the programming phase, it is possible that the energy savings from lighting can be offset by an increase in cooling energy.

Degree of Specialization

As Christopher Alexander noted in his 1977 book, *A Pattern Language*, "Buildings, neighborhoods, and even cities can be built without plans if the makers share a common language." He cites as an example some of the grand cathedrals of Europe, built entirely without written plans. The language he was referring to consists of the basic patterns that generate pleasing, functional spaces—patterns that, without thinking, were copied by generations of people and automatically provided such benefits as appropriate daylighting, comfortable temperatures, and efficient use of materials. The shared language began to evaporate with the specialization that workers developed to use new materials such as steel and also from the changes that were possible after the invention of the air conditioner and electric light.

Buildings have steadily grown in size and complexity to the point where it is probably impossible for a single person to coordinate the design and construction of a modern high-rise building. In addition to the physical differences in modern buildings, the market actors who design and construct modern buildings are highly compartmentalized. Architects do not test the structural integrity of their own designs. Engineers do not have input on wall or flooring materials.

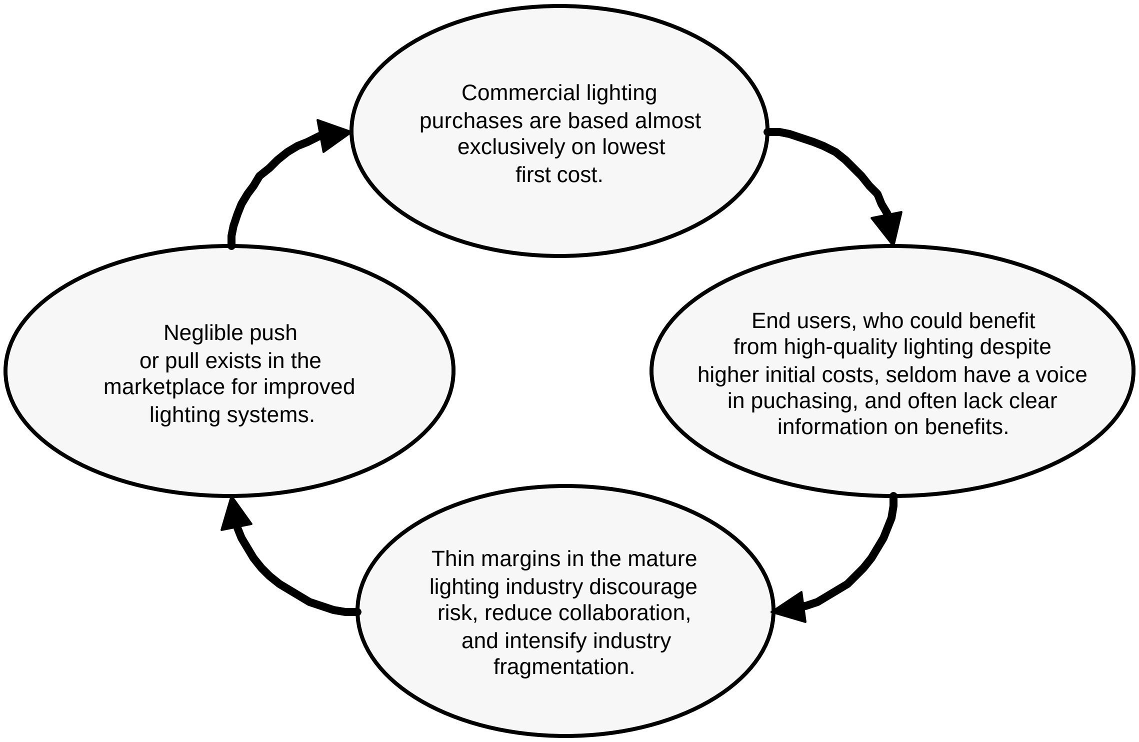
So while each of the disciplines ensures that it's piece of the project will be adequate, there are very few opportunities to change standard practices or to do better than standard. This means that there is a great deal of inertia because of the difficulty in communicating the intent behind specifying something new or unusual. Imagine the consternation of an architect who specifies a high-performance glazing for skylights in a daylighted office and finds out the contractor has substituted a cheaper and lower performance option to save money. The contractor believes he is doing his job by finding savings for the project while installing what he believes to be (though in ignorance) equivalent-quality materials. The architect is frustrated because now the occupants will be less comfortable from the heat through the skylights and the chiller may be undersized. The intent of the specification was not communicated, a potential success may now be a failure, and, as a result, there is little motivation for the designers to take the risk required to achieve an energy-efficient design again in the future.

A closely related and overlapping barrier is the result of thin profit margins inherent in the intensely competitive new construction market. Figure 3-6 (on next page) is a graphical representation of the cycle perpetuating the inertia behind typical lighting practice.

3.2.2 Lack of End-User Demand for Advanced Lighting

There is a clear lack of end-user demand for advanced lighting. In this study, lighting designers reported that they were asked by their clients in less than 3 percent of cases to include daylighting in their designs. While studies exist documenting productivity increases, improvement in sales, and long-term operating cost savings resulting from advanced lighting, the information is either not credible, not yet widely available to the vast majority of end users, or has not yet adequately addressed the barriers noted above.

Figure 3-6
Cost vs. Quality: A Vicious Cycle
Reprinted from Vision 2020, The Lighting Technology Roadmap, March 2000.



3.2.3 Lack of Professional Knowledge

Lighting designers, distributors, and electrical contractors lack basic knowledge about controls and daylighting theory. Typical responses in this study as to why a daylighting system with dimming controls should *not* be installed included, "The climate is too cloudy" and "We don't want to cut into our profits by reducing the amount of equipment we sell." We also found an almost complete lack of knowledge about the relevance of thermal mass, building siting, and glazing technologies in a daylighting design.

3.2.4 Distributor Disincentive to Promote Advanced Technologies

At the largest scale, to achieve the same revenues selling compact fluorescent lamps as incandescent lamps, a distributor must expend a lot more effort advertising and educating buyers. Incandescent lamps require no education and minimal advertising. Therefore, despite the higher sales margins of some efficient technologies, there is a disincentive to push them because of the amount of extra time required to educate and advertise. Also, our previous research, reaffirmed in this study, showed that most distributors see themselves as order fillers or "market responders" not market leaders.

3.2.5 Control Technology Failure and Reputation

Many control systems are difficult to install as designed and require on-going commissioning to maintain the savings sought in the design intent. This tends to be true for both complex controls, such as daylight-controlled dimming, and simpler occupancy-type control systems. For example, Pacific Gas and Electric Company reported at the ACEEE informal session on nonresidential lighting initiatives (discussed in Section 2 and Appendix A of this report) that a photosensor dimming controls study they conducted found that only 2 out of 10 installed systems actually worked as designed without modifications. In addition, there continue to be challenges associated with proper installation and maintenance of occupancy sensors, especially when installed by an untrained contractor or do-it-yourselfer. There is also a lack of "plug-and-play" capability and a lack of standards across the many different components sold across controls manufacturers.

4 POPULATION AND SAMPLE CHARACTERISTICS

This section presents basic characteristics of the Pacific Northwest (PNW) target populations and samples analyzed in this study. We begin by discussing the population and sample characteristics of the market actors studied, followed by a summary of the end-user population and load in the PNW.

4.1 PACIFIC NORTHWEST MARKET ACTORS

This subsection describes the business populations of the contractors, distributors and designers working with commercial and industrial lighting in the PNW. First, we present the population totals for the Standard Industrial Classification (SIC) codes from which we sampled. Next, the portions of the target SIC populations that comprised the study sampling frame are described. We then provide the target versus completed numbers of interviews by market actor. Last, we provide descriptions of the business characteristics of the sample respondents, including average numbers of employees and revenues.

4.1.1 Population Frames

Although SIC categorizations used by various industry data sources are known to be problematic with respect to accurate identification of the very specific types of market actors one seeks to interview on energy-efficiency related topics, they are, nonetheless, one of the best tools available to aid efforts to estimate populations of key market actors. When selecting SICs for inclusion in a population frame, there is a tradeoff between selecting those SICs that one believes will provide a high hit rate of the target market actor (i.e., those for which the SIC codes are mostly accurate and related to the target in mind) and those SICs that are believed to have low hit rates (i.e., those that have lower classification accuracy rates or SICs that are less related to the target business type). In theory, the low hit rate SICs still must be considered because they may, in aggregate, represent a significant portion of the total population. In practice, not all of the possible SICs that may include members of the target population can be surveyed[7]. Our approach was to use our past experience, visual review of firm names by SIC group, and cross-matching of firm names known to be in the target groups (obtained from industry groups and other sources), to assess which SIC categories to include in our population frames.

We used the April-June 2000 Dun & Bradstreet's *MarketPlace*™ database (D&B) as the database source for developing our initial frames. In Tables 4-1 through 4-3, we present population summaries of the SIC codes used. We refer to these as the "unadjusted" totals. These figures are later adjusted,

[7] For example, consider the extreme case in which a target member may have an SIC that is incorrect and shows up randomly in an SIC totally unrelated to the target business type.

as we will describe, based on the accuracy of the hit rate we obtained when surveying members. These tables present total numbers of businesses, employees, sales and average employment and sales data.

Table 4-1
Unadjusted Population of Lighting Contractors
(Sales in $Millions)

	SIC Code	Description	No Bus	Total Empl	Total Sales	Avg Empl	Avg Sales
Contractors	1731-9903	General electrical contractor	800	9,070	1,114	11	1.5
(West)	1731-9904	Lighting contractor	19	138	9	7	0.5
	7349-0105	Lighting maintenance service	14	49	3	4	0.2
		Subtotal	833	9,257	1,125	11	1.4
Contractors	1731-9903	General electrical contractor	548	3,660	360	7	0.7
(East)	1731-9904	Lighting contractor	9	53	7	6	0.9
	7349-0105	Lighting maintenance service	4	11	0	3	0.1
		Subtotal	561	3,724	367	7	0.7
Contractors	1731-9903	General electrical contractor	1,348	12,730	1,473	9	1.2
(All)	1731-9904	Lighting contractor	28	191	16	7	0.6
	7349-0105	Lighting maintenance service	18	60	3	4	0.2
		Total Contractors	1,394	12,981	1,492	9	1.2

Table 4-2
Unadjusted Population of Lighting Distributors

(Sales in $Millions)

Region	SIC Code	Description	No Bus	Total Empl	Total Sales	Avg Empl	Avg Sales
Distributors (West)	5063-0000	Electrical apparatus and equipment	236	2,004	764	9	6.0
	5063-0400	Lighting fixtures	84	551	77	7	1.2
	5063-0401	Light bulbs and related supplies	21	141	9	7	0.7
	5063-0402	Lighting fittings and accessories	1	1	0	1	0.1
	5063-0403	Lighting fixtures, commercial and industrial	22	118	44	5	2.3
	5063-9904	Motor controls, starters and relays: electric	6	54	1	9	0.3
	5063-9905	Motors, electric	23	173	15	8	1.3
		Subtotal	393	3,042	910	8	3.7
Distributors (East)	5063-0000	Electrical apparatus and equipment	86	584	48	7	1.3
	5063-0400	Lighting fixtures	26	104	18	4	0.7
	5063-0401	Light bulbs and related supplies	8	24	3	3	0.4
	5063-0402	Lighting fittings and accessories	0	0	0	0	0
	5063-0403	Lighting fixtures, commercial and industrial	3	20	3	7	0.9
	5063-9904	Motor controls, starters and relays: electric	3	45	4	15	2.1
	5063-9905	Motors, electric	6	113	12	19	2.9
		Subtotal	132	890	88	7	1.1
Distributors (All)	5063-0000	Electrical apparatus and equipment	322	2,588	812	8	4.7
	5063-0400	Lighting fixtures	110	655	95	6	1.1
	5063-9905	Motors, electric	29	165	12	6	0.62
	5063-0403	Lighting fixtures, commercial and industrial	1	1	0	1	0.1
	5063-0401	Light bulbs and related supplies	25	138	47	5	2.1
	5063-9904	Motor controls, starters and relays: electric	9	99	5	11	0.9
	5063-0402	Lighting fittings and accessories	29	286	27	10	1.6
		Total Distributors	525	3,932	998	8	3.0

Table 4-3
Unadjusted Population of Lighting Designers
(Sales in $Millions)

	SIC Code	Description	No Bus	Total Empl	Total Sales	Avg Empl	Avg Sales
Designers (West)	8711-9905	Electrical or electronic engineering	121	776	52	6	0.5
	8712-0000	Architectural services	1,227	7,013	673	6	0.6
	8712-0100	Architectural engineering	21	72	5	3	0.3
	8712-0101	Architectural engineering	59	513	36	9	0.7
		Subtotal	1,428	8,374	766	6	0.6
Designers (East)	8711-9905	Electrical or electronic engineering	48	572	61	12	1.5
	8712-0000	Architectural services	341	1,677	101	5	0.3
	8712-0100	Architectural engineering	4	16	1	4	0.3
	8712-0101	Architectural engineering	28	248	22	9	0.8
		Subtotal	421	2,513	185	6	0.5
Designers (All)	8711-9905	Electrical or electronic engineering	169	1,348	113	8	0.8
	8712-0000	Architectural services	1,568	8,690	774	6	0.5
	8712-0100	Architectural engineering	25	88	6	3	0.3
	8712-0101	Architectural engineering	87	761	58	9	0.7
		Subtotal	1,849	10,887	951	6	0.5

As mentioned above, the unadjusted population figures presented in Tables 4-1 through 4-3 may not include all SICs that have members of the target populations; however, it is cost prohibitive to find such members if they are listed in D&B under non-target SICs because they occur with very low frequency in these other groups. However, the SICs we selected are reasonably inclusive. Fewer than 10 percent of contractor listings we obtained from other sources were not included in D&B SIC categories identified in our target population. While this inclusiveness means that few appropriate businesses were left out, it also means that a significant number of inappropriate businesses were included in the sample population.

4.1.2 Relevant Populations of Study Actors

In an effort to present the relevant populations of contractors, distributors, and designers, we adjusted the population frames to more accurately reflect the number of eligible business in the population based on the results of sampling. We created call lists from which to sample based on the number of expected completes from the unadjusted populations shown in Tables 4-1 to 4-3. (The methods used for the creation of call lists are discussed in Section 4.1.2.) To minimize errors, we developed screening criteria for each market actor so that interviews would be completed only with true members of the target populations. For example, we purposefully screened out the firms that did extremely small volumes of C&I lighting business. A summary of the percentage of firms that met our screening criteria is provided in Table 4-4. The screening criteria are provided in Appendices B and C.

Table 4-4
Percent of Firms Who Met Screening Criteria to Qualify for Surveys

Status	Distributors	Contractors	Designers
Eligible	71%	57%	46%
Ineligible	29%	43%	54%

Most of the ineligible designer firms were architectural companies that subcontract the majority of their lighting work to electrical engineers. For the distributors, the majority of ineligible firms only sold retail or residential lighting products, or they sold little or no lighting in their electrical distribution business. A majority of the ineligible contractor listings were disconnected phones or wrong numbers.

We adjusted the overall population numbers in Tables 4-1 through 4-3 downward to estimate the number of eligible businesses in the population. The adjusted values presented in Table 4-5 are considered to be our best estimates of the populations for the purposes of this study. These figures could be refined further with additional research focused specifically on the issue of population estimation.

Table 4-5
Adjusted Population of All Study Actors
(Sales in $Millions)

	SIC Code	Description	Adj Factor	No Bus	Total Empl	Total Sales
Contractors	1731-9903	General electrical contractor	0.60	811	7,655	886
(All)	1731-9904	Lighting contractor	0.31	9	59	5
	7349-0105	Lighting maintenance service	0.44	8	27	1
	n/a	Referrals outside of D&B	1.00	1	5	0.3
		Contractor Total	*0.57*	*829*	*7746*	*892*
Distributors	5063-0000	Electrical apparatus and equipment	0.77	249	2003	628
(All)	5063-0400	Lighting fixtures	0.72	79	472	68
	5063-0401	Light bulbs and related supplies	0.72	18	100	9
	5063-0402	Lighting fittings and accessories	0	0	0	0
	5063-0403	Lighting fixtures, commercial and industrial	0.67	1	1	0
	5063-9904	Motor controls, starters and relays: electric	0.43	4	42	2
	5063-9905	Motors, electric	0.42	12	69	5
	n/a	Referrals outside of D&B	0.94	19	152	57
		Distributor Total	*0.71*	*382*	*2838*	*770*
Designers	8711-9905	Electrical or electronic engineering	0.52	88	705	59
(All)	8712-0000	Architectural services	0.41	639	3540	315
	8712-0100	Architectural engineering	0.00	0	0	0
	8712-0101	Architectural engineering	0.38	33	285	22
	n/a	Referrals outside of D&B	0.46	18	126	10
		Designer Total	*0.46*	778	4,656	406

To understand the overall distribution of business organizations by sub-region, we looked at the characteristics of the entire business market for the PNW. Table 4-6 shows that the western portions of Oregon and Washington have about twice the number of commercial businesses of all types, and three times the revenues compared with the eastern portions of those states plus Idaho and Montana. The dividing line between the western and eastern regions used was 121.5° west longitude, which represents a proximate value for the Cascade Mountains. The choice of a specific longitude value facilitated separation of the Dun & Bradstreet listings because of the existing latitude/longitude classification. As Shown in Table 4-7, we then compared the revenues of the estimated populations of commercial lighting market actors by sub-region to the breakdown for the entire population of businesses. From this, it is clear that sales for both electrical contractors and lighting designers were proportional to all sales in the east and west, but that lighting distributor sales were weighted more heavily to the populated western region.

Table 4-6
Entire Business Population of All Types in Pacific Northwest

Region	Number Businesses		Total Employees		Total Sales in $Millions	
West	384,917	68%	3,590,949	71%	548,833	78%
East	184,656	32%	1,483,677	29%	150,709	22%
All	569,573	100%	5,074,626	100%	699,542	100%

Source: Dun & Bradstreet's MarketPlace Apr-Jun 2000

Table 4-7
East-West Comparison of Contractors, Distributors, Designers

	Number Businesses		Total Employees		Total Sales in $Millions	
Contractors						
West	475	*60%*	5,276	*71%*	641	*75%*
East	320	*40%*	2,123	*29%*	209	*25%*
Distributors						
West	279	*75%*	2,160	*77%*	646	*91%*
East	94	*25%*	632	*23%*	62	*9%*
Designers						
West	556	*76%*	3,417	*78%*	309	*81%*
East	176	*24%*	964	*22%*	73	*19%*

Source: Dun & Bradstreet's MarketPlace Apr-Jun 2000

4.1.3 Call Lists

Success rates from past surveys with the target populations were used to help decide how large a call list was warranted for each type of market actor. Based on our past experience, we knew that distributors would be relatively easy to complete surveys with because their jobs keep them close to phones. A ratio of 5 contacts per complete survey is usually sufficient. Historically, contractors have been far more difficult to reach because they are regularly out of the office during the daytime. Therefore, we used a ratio of 20:1. Designers are usually available in their offices, however, they are often busy during daytime hours and sometimes reluctant to take time away from projects for an interview. Therefore, we used a ratio of 10:1 for designers.

For many of the SIC categories we pulled purely random samples from our call lists. In a few cases, however, more refined approaches were used. For example, in some cases we pre-screened the initial call lists generated by D&B to eliminate businesses that were obviously ineligible simply based on company name (e.g., Arrow Theatrical Lighting Co., Quinty Automotive). For designers, we found that the best sources of information for identifying the electrical engineers with the most significant part of the lighting business in PNW was to use referrals provided to us by the architects who said they use electrical engineers for their plans and specifications. In addition, we attempted to balance market representation of common actors with a diversity of viewpoints. For instance, only a few lighting contractors and lighting maintenance companies exist in the PNW, while there are well over 1000 general electrical contractor companies. We therefore included all 27 lighting contractor firms and all 17 lighting maintenance service companies, but sampled a total of 603 general electrical contractors from a pool of 1,348. For all of these reasons, as well as the difficulties in estimating the true population frames for the market actors in questions, the samples conducted for this study are a mix of statistical and convenience samples. We believe this is the most appropriate approach for a study of this scope and one that has resulted in reliable results.

Tables 4-9 through 4-11 present the call lists by SIC code and size of company. The businesses are categorized as small, medium, and large, based of the total number of full-time-equivalent employees at the location where the interview was conducted. The size breakdown is illustrated in Table 4-8.

As is clear in Tables 4-9 through 4-11, we purposefully over-sampled large firms to ensure statistical validity of the responses of these key market players.

Table 4-8
Definition of the Full-Time-Equivalent (FTE) Employee-Based Size Categories

Size	Employees
Small	1 to 9
Medium	10 to 24
Large	25 and up

Table 4-9
Number of Firms in the Distributor Call List by FTE Size Category and SIC

SIC Code	Description	Small 1-9	Medium 10-24	Large 25-249	Total
5063-0000	Electrical apparatus and equipment	164	53	8	225
5063-0400	Lighting fixtures	90	16	4	110
5063-0401	Light bulbs and related supplies	22	5	2	29
5063-0402	Lighting fittings and accessories	1	0	0	1
5063-0403	Lighting fixtures, commercial and industrial	21	3	1	25
5063-9904	Motor controls, starters and relays: electric	6	2	1	9
5063-9905	Motors, electric	17	10	2	29
	Totals	*321*	*89*	*18*	*428*

Table 4-10
Number of Firms in the Designer Call List by FTE Size Category and SIC

SIC Code	Description	Small 1-9	Medium 10-24	Large 25-499	Total
8711-9905	Electrical or electronic engineering	108	16	5	129
8712-0000	Architectural services	167	47	47	261
8712-0100	Architectural engineering	2	0	1	3
8712-0101	Architectural engineering	11	4	6	21
	Totals	*288*	*67*	*59*	*414*

Table 4-11
Number of Firms in the Contractor Call List by FTE Size Category and SIC

SIC Code	Description	Small 1-9	Medium 10-24	Large 25 +	Total
1731-9903	General electrical contractor	411	89	103	603
1731-9904	Lighting contractor	22	2	3	27
7349-0105	Lighting maintenance service	15	2	0	17
	Totals	*448*	*93*	*106*	*647*

4.1.4 Interview Targets and Completes

The goals for primary data collection were set at 30 contractors, 30 designers, and 60 distributors. Table 4-12 shows the SIC code mapping for these target interviews.

Table 4-12
Target Surveys and SIC Code Mapping

Number	SIC Code	Description
30 Contractors	1731-9903	General electrical contractor
	1731-9904	Lighting contractor
	7349-0105	Lighting maintenance service
30 Designers	8711-9905	Electrical or electronic engineering
	8712-0101	Architectural engineering
	8712-0000	Architectural services
	8712-0100	Architectural engineering
60 Distributors	5063-0000	Electrical apparatus and equipment
	5063-0400	Lighting fixtures
	5063-0401	Light bulbs and related supplies
	5063-0402	Lighting fittings and accessories
	5063-0403	Lighting fixtures, commercial and industrial
	5063-9904	Motor controls, starters and relays: electric
	5063-9905	Motors, electric

Beyond overall numbers of target interviews, we wanted to ensure that firms from both sides of the Cascades were represented. Our rough goal was to get about 60 percent of the results from the western region and 40 percent from the eastern region, even though the population is somewhat more skewed toward the west, with 68 percent of the businesses located there.

Tables 4-13 through 4-15 show our interview targets and the number of actual completed interviews.

Table 4-13
Distributors: Interview Target Goals and Completes

	Targets			Completes		
	East	West	Total	East	West	Total
Large	4	8	12	1	11	12
Medium	9	12	21	9	11	20
Small	12	15	27	14	14	28
Total	*24*	*36*	*60*	*24*	*36*	*60*

Table 4-14
Designers: Interview Target Goals and Completes

	Targets			Completes		
	East	West	Total	East	West	Total
Large	4	6	10	2	10	12
Medium	4	6	10	5	3	8
Small	4	6	10	5	5	10
Total	*12*	*18*	*30*	*12*	*18*	*30*

Table 4-15
Contractors: Interview Target Goals and Completes

	Targets			Completes		
	East	West	Total	East	West	Total
Large	5	5	10	7	9	16
Medium	5	5	10	3	4	7
Small	5	5	10	3	4	7
Total	*12*	*18*	*30*	*13*	*17*	*30*

We were aware at the outset that it would be more difficult to complete interviews with small and medium size contractor firms than with large ones. Because the contractor interviews were conducted under an accelerated schedule, we were not able to keep to the original quotas for the small and medium segments. Thus, the results are skewed toward the larger businesses.

4.1.5 Distributor Sample Characteristics

A majority of the 60 distributors interviewed described themselves either as ‘electric equipment suppliers’(37%) or ‘general industrial suppliers’ (25%). The remaining distributors were split between ‘manufacturer representatives’ (22%) and ‘lighting suppliers’ (17%). For the eastern region, we found that there were few large distributorships to interview. The majority of firms interviewed were small (1 to 9 employees) or medium (10 to 24), with small being the most common. In the western region, there was significantly more diversity in the size of the firms we interviewed. Of the 36 respondents, 11 were classified as large companies, another 11 were medium, and 14 were small.

For companies with 25 or more employees (large), the average revenues at the location called was $28 million. Company locations with between 10 and 24 employees (medium) reported average revenues of $7 million, and firms with 9 or fewer employees (small) averaged $2.4 million in annual revenues. Of these reported revenues, the fraction derived from lighting equipment is half for the medium and large firms and three-quarters for the small firms.

Distributors were also asked to provide the number of projects per year for which they provided lighting specification or design services. Small companies reported an average of 65 projects, medium firms 20, and large companies 45. One reason that large and medium companies in the west may specify, design, or lay out lighting somewhat less frequently than small companies is that they may tend to focus more on inventory and sales than design work. Also, smaller firms are more likely to specialize in the supply of lighting products, and these firms may be more likely to provide significant design assistance work. In any case, the sample sizes are not large enough to discern meaningful differences among firms based on their size. In addition, the number of lighting specification projects should not be confused with the volume of such projects in terms of sales, since larger firms likely are more involved in larger projects.

4.1.6 Contractor Sample Characteristics

The business characteristic questions asked of contractors differed from those asked of distributors because contractors primarily install rather than sell lighting equipment as their core competency[8]. Contractors do, however, make recommendations for changes and sometimes re-specify equipment due to availability, cost, or suitability issues. Over 90 percent of the surveyed contractors characterized themselves as 'electrical contractors'; the remaining 10 percent called themselves 'lighting contractors.'

For companies with 25 or more employees (large), the average revenues at the location called was $9.3 million. Company locations with between 10 and 24 employees (medium) reported average revenues of $2.1 million, and firms with 9 or fewer employees (small) averaged $1.3 million in annual revenues. Contractors gave very consistent answers when we asked them what percent of their annual revenue was directly related to commercial and industrial lighting work. Both the east and west reported that an average of 40 percent of their company's annual revenue is related strictly to commercial and industrial lighting. Interviewees often stated that lighting is tied into all or many parts of an electrical contractor's job; thus, they do not normally separate revenues from lighting installations from other areas of their projects.

The numbers of annual C&I lighting jobs reported varied significantly, from a single, large project to well over 100. Large firms averaged around 70 jobs per year that involved installation or retrofit of lighting equipment. Medium firms averaged around 20 jobs and small firms about 25. As one would expect, the average size of jobs is substantially higher for large and medium than for small contractors.

On some of their jobs, contractors provide the original equipment specifications. *We found that contractors specify equipment on roughly a third of their projects.* This includes both the initial specification and cases where the contractors significantly changed an architect's or electrical engineer's specification.

4.1.7 Designer Sample Characteristics

For designers in both the east and west, the types of firms we interviewed were similar. About a third of all respondents described their company as architectural. Another third said they are consulting engineers, and the remaining third electrical engineers. Large designers averaged revenues of $9 million, medium companies around $1.3 million, and small roughly $600,000. There was consistency among the various sized companies interviewed that about 30 percent of their revenues are related to lighting design work. There appear to be many more large architectural or engineering firms in the west than in the eastern region.

In terms of the numbers of projects in which firms provided some design, layout, or specification of lighting equipment, the eastern and western regions differed significantly. In the East, medium and small companies have roughly 65 jobs per year. In the West, where larger design firms dominate the market,

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[8] However, contractors do earn a margin on the pass-through of equipment sales

the small- and medium-size firms have fewer projects—around 20. Large designer firms averaged over 100 jobs per year west of the Cascades. East of the Cascades, the average is less at 35 jobs per year.

Daylighting "Sub" Interviews

In some cases, we did not attempt to complete interviews with architects called that made extensive use of a separate electrical engineering firm for the detailed level specification and layout. When we encountered such an architect we attempted to interview the engineering firm with which they were associated. We also tried to gauge the architects' involvement in the overall lighting design process. For those architects who reported that they are significantly involved in coordinating the lighting design process but who do little to none of the specification and layout work, we asked only the daylighting questions on the designer survey. Four of these surveys were completed, with three large architectural firms and one medium firm. Though few in number, these interviews provided additional insight into the use of daylighting in Washington and Oregon.

4.2 PNW End-Use Lighting Consumption

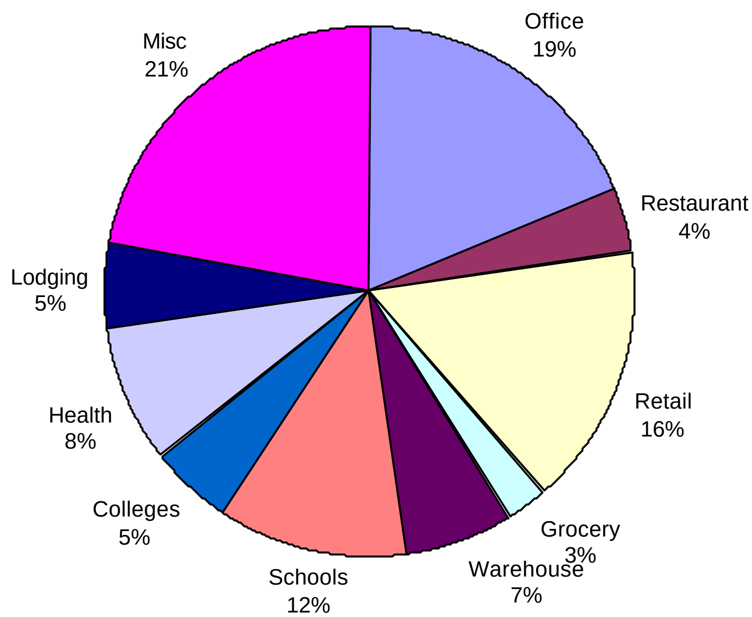
Though primary research with end users was not within the scope of this study, we have attempted to incorporate existing information on the basic load characteristics of the end user market. Much of the information in this section is based on estimates of base usage developed by the Northwest Power Planning Council (NWPPC) through its end-use forecasting model[9]. The Northwest Power Planning Council provided end-use energy estimates in average megawatts and end-use intensities in kWh/ft^2 for existing and new construction in the PNW. We have summarized the shares of major lighting technology groups by building type using these data and data from additional sources, such as the recent Alliance-sponsored baseline study of new construction in the region.

4.2.1 Commercial End-User Population

In Figure 4-1, we provide a breakdown of regional commercial floor space for the existing construction market in 2000 (based on the NWPPC forecast). As shown in Figure 4-1, Office, Retail, and Education (Schools and Colleges), account for over half of the floorspace .

[9] The end-use forecasting model was last calibrated in 1995.

Figure 4-1
Percent of Floor Space by Building Type for the PNW
(Total = 2.7 billion square feet)



To complement the NWPPC forecast numbers, we analyzed the Dun & Bradstreet (D&B) database of nonresidential customers by size (in terms of full-time-equivalent employees) and business type. The result is shown in Table 4-16. There are approximately half a million nonresidential establishments in the PNW, with the vast majority having fewer than 25 employees. The percentage of establishments for Office and Retail from D&B is close to the percentage of floor space in the NWPPC forecast. In previous work we have confirmed that D&B provides a reasonable estimate of the number and type of nonresidential establishments in a region.

Table 4-16
Estimated Number of Establishments by Type and FTE in the PNW
Source: Dun & Bradstreet MarketPlace 2000

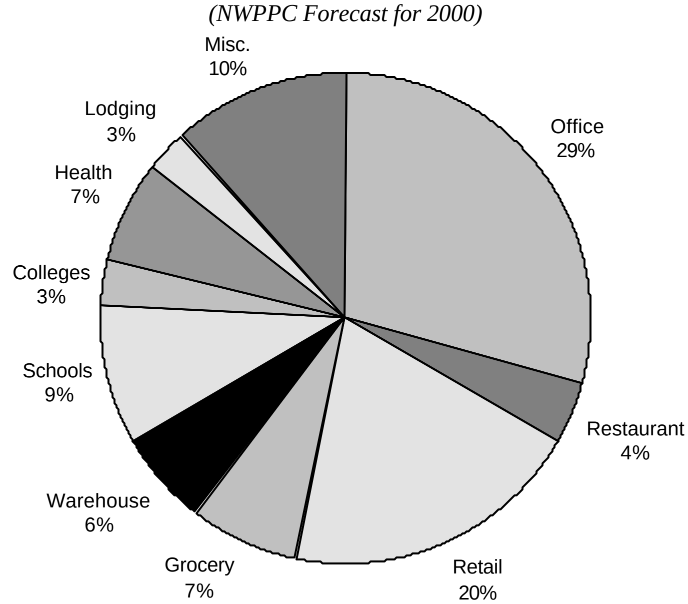
Type	1-4 FTE	5-24 FTE	25-99 FTE	100+ FTE	Unknown	Total	Percent
Office	69,042	17,862	3,033	602	2,071	92,610	17%
Retail	59,574	28,803	6,213	1,057	6,675	102,322	18%
Institutional	19,777	11,905	5,814	1,812	3,850	43,158	8%
Other	164,777	42,736	7,798	1,469	5,195	221,975	40%
Industrial	72,840	19,379	4,410	1,445	1,621	99,695	18%
Total	*386,010*	*120,685*	*27,268*	*6,385*	*19,412*	*559,760*	*100%*

4.2.2 End-Use Shares

According to the NWPPC's forecast, lighting load for the entire existing building stock in 2000 should have been roughly 1613 aMW. Figure 4-2 shows the breakdown of building lighting end-use shares by building type. The percentages presented here are for existing buildings; however, according to the NWPPC forecast, the shares for new construction are nearly equivalent. According to the NWPPC forecast, the total new construction lighting load is roughly 41 aMW per year over the 2001 to 2010 period. This amounts to about a 2.5 percent increase per year. The importance of Office and Retail is even greater on the basis of lighting consumption than on the basis of square footage; together they represent an estimated 49 percent of regional commercial lighting consumption.

The relative intensity of lighting use varies with the building type as shown in Figure 4-3. Grocery EUIs are highest because of the their high annual hours of use and moderately high lighting power densities (LPDs). Retail stores typically have high LPDs but moderate annual hours of use. Education facilities and lodging tend to have fairly low average hours of use.

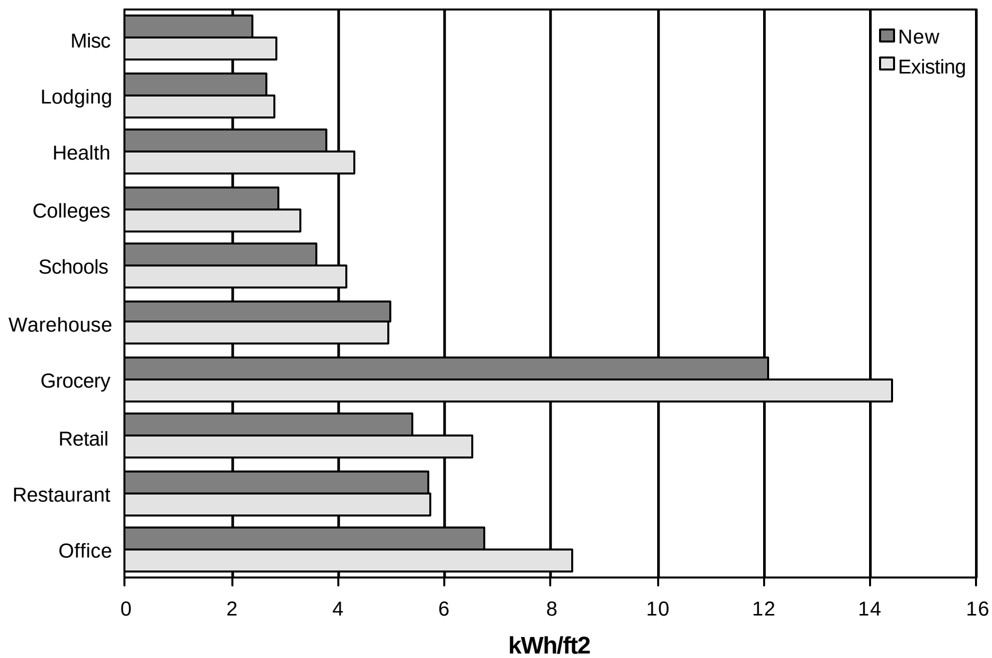
Figure 4-2
Existing Construction
Lighting End-Use Shares by Building Type
(NWPPC Forecast for 2000)



Total = 1613 aMW

Source: Northwest Power Planning Council End Use Forecast (note: last calibrated in 1995).

Figure 0-3
Lighting EUIs by Building Type: New and Existing Buildings



Source: Northwest Power Planning Council End Use Forecast (note: last calibrated in 1995).

4.2.3 Breakdown of Fixture Types

There are a myriad of lighting technologies available for commercial use. Fortunately, there is a discrete set of basic technology type and size categories into which most of these individual technologies can be categorized. A summary of basic lamp types, as percentages of connected load in buildings, is shown in Table 4-17 for buildings recently constructed in the PNW based on the results of the Alliance's recent new construction baseline study. As shown in the Table 4-17, T8 lamps represent almost 90 percent of linear fluorescent lighting in new construction.

No current data exists on the breakdown of base fixture types within the existing construction market in the PNW. As a result, we used estimates of fixture shares we developed from PNONRES[10]. Despite the fact that the PNONRES survey is dated, the basic distribution of fixture types has probably not changed significantly in the existing stock. These are shown in Table 4-18.

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[10] BPA, 1991a. *Pacific Northwest Non-Residential/Commercial Energy Survey (PNonRES), Phases I and II Descriptive Data Analysis Report*, Bonneville Power Administration, December. BPA, 1991b. *Pacific Northwest Non-Residential/Commercial Energy Survey (PNonRES), Volume 5: Analyst's Guide to PNonRES*, Bonneville Power Administration, February.

Table 4-17
Pacific Northwest Connected Lighting Load in New Commercial Buildings by Lamp and Ballast Type

Reprinted from Ecotope's Baseline Characteristics of the Nonresidential Sector in ID, MT, OR and WA, Mar 2000

	Ballast Type			
Lamp Type	**Unk / NA**	**MagEE**	**Electronic**	**Total**
Fluorescent				
F32T8	3.0%	3.4%	44.4%	50.8%
F40/96T12	1.4%	3.8%	0.7%	5.9%
Compact	1.6%	0.7%	2.2%	4.5%
Other Fluorescent	0.2%	0.3%	0.8%	1.3%
HID				
Metal Halide	25.1%	-	-	25.1%
HP Sodium	2.1%	-	-	2.1%
Mercury Vapor	0.3%	-	-	0.3%
Incand & Unknown				
Incandescent	8.6%	-	-	8.6%
Low-Voltage Incand	0.9%	-	-	0.9%
Unknown Type	0.5%	-	-	0.5%
Totals	*43.7%*	*8.2%*	*48.1%*	*100%*

Table 4-18
Existing Buildings
Fixture Shares by Building Type

	4-foot Fluor	8-foot Fluor	Incand <150 W	Incand >150 W
Offices	82%	3%	15%	1%
Restaurant	22%	2%	73%	2%
Retail	45%	25%	22%	8%
Grocery	32%	57%	11%	0%
Warehouse	41%	29%	29%	1%
Schools	60%	7%	31%	1%
Colleges	60%	7%	31%	1%
Health	57%	1%	40%	2%
Lodging	9%	1%	88%	2%
Other	35%	6%	56%	3%

Source: XENERGY estimate.

Using a combination of the PNONRES and NWPPC forecast data, along with average hours of operation and watts per fixture developed in a previous XENERGY study in the PNW[11], we have estimated the total number of fixtures by type for both existing buildings. For new construction the total number of fixtures is based on the Alliance/Ecotope study. The resulting estimates are shown in Table 4-19.

[11] XENERGY support of PGE DSM Potential Forecasts, mid-1990s.

Table 4-19
Estimated Numbers of Fixtures by Lamp Type in Pacific Northwest Commercial Spaces

Lamp Type	Existing Buildings (Millions)	New Buildings (Millions/Yr)
4-foot Fluorescent	11.3	1.58
8-foot Fluorescent	5.8	0.27
Incandescent < 150W	17.1	2.24
Incandescent >= 150W	3.5	0.08
Total	*37.6*	*4.17*

Source: XENERGY estimate.

5 BASELINE RESEARCH RESULTS

5.1 SUMMARY OF KEY FINDINGS

The lighting market is changing in the Pacific Northwest. What used to be a region in which the densely populated cities in the western parts of Oregon and Washington had substantially more efficient lighting has changed into an area where many proven high-efficiency lighting technologies have migrated east to Idaho and Montana. This shift is happening despite a lack of mandatory energy codes in those states.

Based on the primary research presented in this section, there are several general conclusions we can draw about the current state of the lighting market in the Alliance's territory:

DESIGN INFLUENCE Electrical engineers are most influential over choices in lighting equipment, controls and layout. In addition, electrical contractors make design suggestions and changes in a third of projects. Despite this, electrical engineers and contractors are generally not trained in daylighting, and only occasionally get involved early in a project when daylighting opportunities are greatest.

REGIONAL SIMILARITY The usage of efficient lighting equipment is not significantly different in the population centers west of the Cascades and in the more rural eastern areas of Oregon, Washington, and the states of Idaho and Montana. Emerging technologies are used in greater numbers in Seattle and Portland, but as with occupancy sensors, T8 lamps and electronic ballasts, these quickly spread to eastern areas as they are proven.

ELECTRONIC BALLASTS Electronic ballasts are now standard practice. For new purchases that serve both existing and new buildings, distributors report that electronic ballasts made up 67 percent of sales in 1999 versus 43 percent in 1996.

T8 LAMPS T8 lamps are also considered standard practice. From 1996 to 1999, sales of T8 lamps jumped from 34 percent to 61 percent of the four-foot fluorescent market.

CFLS Compact fluorescent lamps have gained considerable market share over the past three years, jumping from 32 percent of downlights and wall sconce sales in 1996 to 49 percent in 1999.

While there are many more lighting specialists in Seattle and Portland than in Spokane and Boise, lighting designers throughout the Alliance's territory are concerned about the increasing speed of construction. Concerns center on the lack of time available to design good lighting systems. Some designers noted that the problem is exacerbated in design-build projects because of the strong orientation to speed. One of the results of more rapid construction is a shift toward modular lighting designs which are copied onto new floorplans, often without regard to building orientation, window size and placement, or lighting in surrounding spaces.

Other important results of our primary research include the following.

On practices:

- More attention is getting paid to comfort and productivity associated with lighting.
- Interest in daylighting is fairly high, but its application is still uncommon.
- Knowledge of fundamental daylighting design principles is limited to a small group of lighting designers.

On technologies:

- Pulse-start metal halide fixtures are widely known and are increasingly used.
- LED exit signs have nearly replaced CFL and incandescent units in new construction.
- T5 lamps will increase their market share in mainstream applications in the next three years. Many designers and distributors regard T5 lamps as an "up-and-coming" technology.
- There are more choices of fixtures with efficient lamp and ballast configurations than there were in the recent past.
- Dimming ballast usage will increase in conjunction with more daylighting design.
- Improvements to dimming equipment and occupancy sensors are expected to substantially quell existing concerns as technology is made more reliable and easier to install and operate.

5.2 ENERGY CODES

Before presenting our primary research, we present two key results from the Alliance's recent study of new construction practices conducted by Ecotope (see Section 2 for citation). The on-site results of lighting power densities from the Ecotope study provide a useful context and corroboration of some of the results we have obtained through self-reported methods. As background to the Alliance/Ecotope lighting results, it is important to understand the current status of energy codes in the region. Idaho and Montana have adopted the Model Energy Code based on ASHRAE Standard 90.1 1989 for their official state codes, however neither state requires compliance. Oregon and Washington have both adopted mandatory state codes that grew out of ASHRAE 90.1, but evolved through public input of local concerns. Table 5-1 provides an overview of the energy code status in the four-state region.

Table 5-1
Energy Codes in the Pacific Northwest

	Idaho	Montana	Oregon	Washington
Code	Model Energy Code based on ASHRAE 90.1 1989	Model Energy Code based on ASHRAE 90.1 1989	Oregon Nonresidential Energy Code (ONEC)	Washington State Non-residential Energy Code (NREC)
Enforcement	Local building departments	Local building departments in metropolitan areas, and the State Architect's Office elsewhere	Mostly by local jurisdictions with some assistance from the State	Local jurisdictions, which have the power to adopt more stringent standards than NREC in some cases
Mandatory?	No	No, except for public buildings which must comply with the stricter Uniform Building Code	Yes	Yes
Office LPD	1.81	1.81	1.23	1.20
Controls Req'd?	No	No	Yes, for ≥ 2,000 ft^2	Yes, for ≥ 5,000 ft^2

Figure 5-1 shows the average lighting power densities in Idaho, Montana, Oregon and Washington that were obtained in the Alliance/Ecotope study. The authors hypothesize that the rather close findings between the four states is due to two factors: (1) typical practice throughout the region is better than the Model Energy Code requires, and (2) the study sample was heavily weighted with government buildings in the eastern part of the region—the only buildings that are subject to energy codes in those states.

Figure 5-1
Average Lighting Power Densities in the Four States
Reprinted from Ecotope's Baseline Characteristics of the Nonresidential Sector in ID, MT, OR and WA, Mar 2000

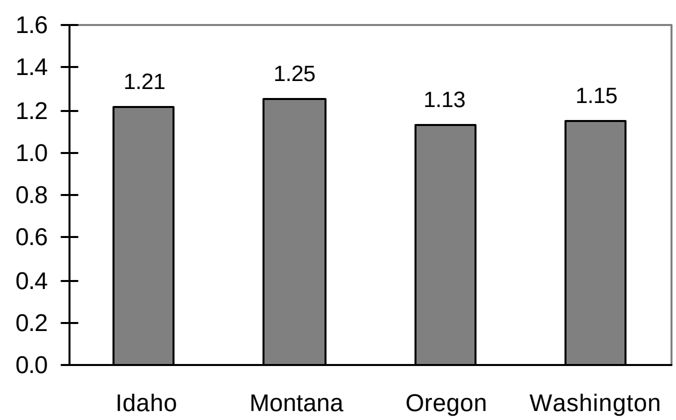


Table 5-2 shows the average lighting power densities observed by Ecotope in twelve building types throughout the region. The two right-hand columns show the space type allowance for the Oregon energy code and for ASHRAE 90.1 1989. Note the observed power densities are less than or equal to the more stringent code in every case.

Table 5-2
Lighting Power Density by Building Type

Reprinted from Ecotope's Baseline Characteristics of the Nonresidential Sector in ID, MT, OR and WA, Mar 2000

Building Type	No. Obs	Average Observed LPD	Oregon Code Allowance LPD	ASH 90.1 Allowance LPD
Assembly	10	1.25	1.30	1.82
Education	21	1.20	1.25	1.59
Grocery	6	1.70	1.83	2.58
Health Services	11	1.25	1.50	1.34
Institution	3	1.13	1.13	1.13
Manufacturing	12	1.03	1.04	1.28
Office	25	1.18	1.23	1.81
Other	15	1.18	1.36	1.34
Residential/Lodging	10	0.76	1.22	1.29
Restaurant / Bar	1	0.94	1.50	1.43
Retail	15	1.30	1.56	1.89
Warehouse	14	0.92	1.07	1.18
All	*143*	*1.17*	*1.31*	*1.60*

5.3 REGIONAL PRODUCT FLOWS

A flow diagram of product purchases and sales is presented in Figure 5-2. The data underlying the diagram were obtained from our interviews with distributors and contractors. Distributors sell close to two-thirds of their commercial and industrial lighting equipment to contractors and builders. A significant fraction, however, was reported to be sold directly to end users. Contractors report that 89 percent of the lighting products they purchase are from distributors, while the remaining portion come directly from manufacturers. Contractors do not report using big box retail or the Internet to purchase lighting products.

Contractors were asked to provide a breakdown of their lighting sales. The breakdown of commercial and industrial contractor lighting installations by sector is shown in Table 5-3. The mix of building types in which new lighting equipment is currently being installed by contractors varies somewhat between the eastern and western regions, with office space making up a larger share of the total in Portland and Seattle, and retail business taking up more in Spokane and Boise. These differences should not be viewed as significant, however, given the small samples by sub-region. In general, the overall shares reported for Office and Retail closely match the estimated lighting load of those sectors presented in Section 4.

Table 5-4 shows contractor installations by the market event. Contractors report that half of their lighting projects are for new construction, a quarter are for major renovation and remodeling, 20 percent for major retrofits of operable equipment, and 5 percent are for equipment failures.

Figure 5-2
Commercial and Industrial Lighting Equipment Purchases and Sales in the Pacific Northwest

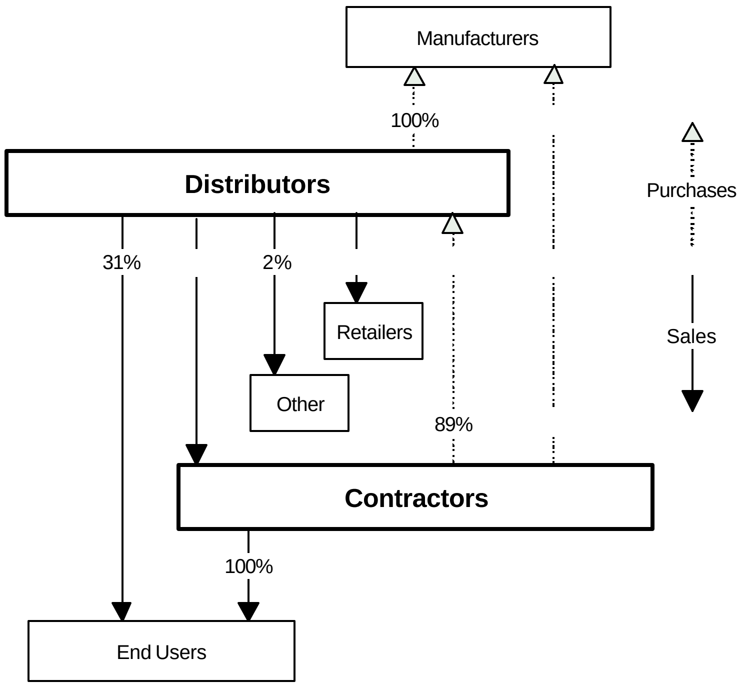


Table 5-3
Contractor Lighting Installations by Industry Sector

Building Type	East	West	All
# Respondents	*13*	*14*	*27*
Offices	21%	40%	31%
Retail	25%	9%	17%
Other Commercial	37%	38%	37%
Industrial	17%	13%	15%
Totals	*100%*	*100%*	*100%*

Table 5-4
Contractor Lighting Installations by Market Event

Market Event	East	West	All
# Respondents	*13*	*15*	*28*
New Construction	45%	55%	50%
Major Renovation and Remodeling	21%	26%	24%
Retrofit of Operable Equipment	27%	16%	21%
Retrofit of Failed Equipment	6%	4%	5%
Totals	*100%*	*100%*	*100%*

5.4 MARKET SHARE BY TECHNOLOGY

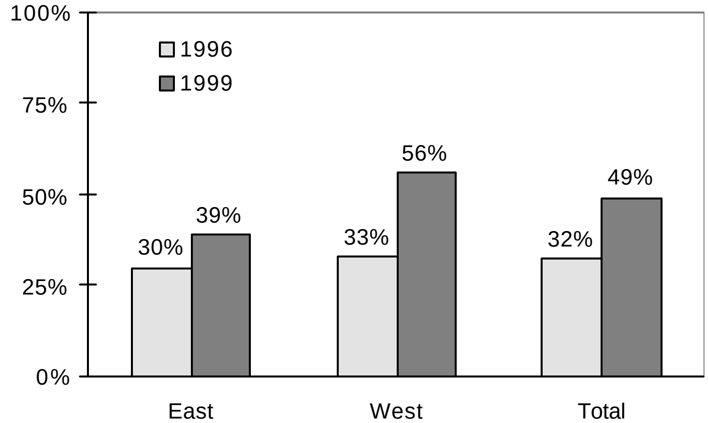
As a whole, the commercial and industrial lighting market of the Pacific Northwest is characterized by many of the same trends as other regions. Market share for compact fluorescent lamps, T8 lamps and electronic ballasts has increased over the past three years; and while occupancy sensors still languish at lower market shares, the trend is toward increasing usage of them as well. T5 lamps and dimming ballasts are reported to have very low market shares of about 3 percent and 1 percent, respectively.

The results presented in the section are based on self reports from the market actors interviewed. It is important to keep in mind that *results for 1996 are retrospective estimates made by the respondents during the interviews.* However, our previous research on commercial lighting has demonstrated that lighting professionals are reasonably able to estimate relative product shares several years into the past.

5.4.1 Compact Fluorescent Lamps

As shown in Figure 5-3, compact fluorescent lamps have gained considerable market share over the past three years in the western region, jumping from 33 percent of wall sconce sales in 1996 to 56 percent in 1999. The eastern region started from about the same share at 30 percent but has only increased to 39 percent.

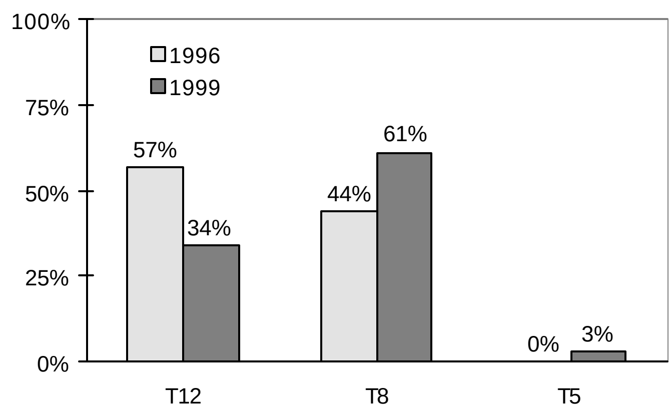
Figure 5-3
Compact Fluorescent Lamps as a Percentage of Distributor Downlight and Wall Sconce Sales, Retrospective Self Reports for 1996 and 1999



5.4.2 Linear Fluorescent Lamps

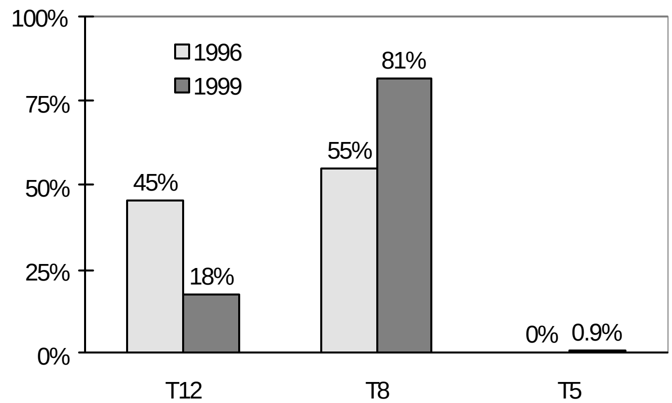
As shown in Figure 5-4, distributors report that the one-inch diameter T8 lamp continues its rise in usage. From 1996 to 1999, distributors report that their sales of T8s increased from 44 percent of their four-foot sales to 61 percent. A corresponding drop in T12 lamp sales was reported, and the T5 lamp rose from no market share to nearly 3 percent.

Figure 5-4
Breakdown of Four-Foot Linear Fluorescent Sales for Distributors, Retrospective Self Reports for 1996 and 1999



Contractors were also asked about their installations of linear tubular fluorescent lamps. As shown in Figure 5-5, they reported a higher incidence of T8 lamps than distributors had reported. This same phenomenon, in which contractors report significantly higher T8 and electronic ballast shares then distributors was observed in a recent California market study as well[12]. The most likely explanation for this is that contractors are involved less with replacing lamps that burn out in existing fixtures (where the share of T12 lamps is large) than with new construction, major renovation, and group replacements, all of which are likely to trigger an upgrade to more efficient equipment. Conversely, smaller customers and customers with on-site maintenance staff are likely to purchase their standard efficiency replacement components directly from distributors. Other possible explanations for the difference include significantly higher percentages of direct purchases by contractors of T8 lamps directly from manufacturers or a systematic bias toward overreporting usage of T8 lamps within the contractor community.

Figure 5-5
Breakdown of Four-Foot Linear Fluorescent Installations for Contractors, Retrospective Self Reports for 1996 and 1999



5.4.3 Linear Fluorescent Ballasts

One of the great energy-efficiency success stories of the 1990s is the strong movement toward using only electronic ballasts with linear fluorescent lamps. As shown in Figure 5-6, in 1996, electronic ballasts accounted for just 32 percent of the linear fluorescent market. This figure is reported to have more than doubled to 67 percent by 1999. As shown in Figure 5-7, contractors again reported an even higher share of electronic ballasts, saying they make up an average of 80 percent of their installations.

[12] XENERGY, Inc. 2000. 1999 State-Level Small/Medium Nonresidential MA&E Study Draft Final Report. Prepared for the California Board for Energy Efficiency/Pacific Gas and Electric Company.

Figure 5-6
Breakdown of Linear Fluorescent Ballast Sales for Distributors, Retrospective Self Reports for 1996 and 1999

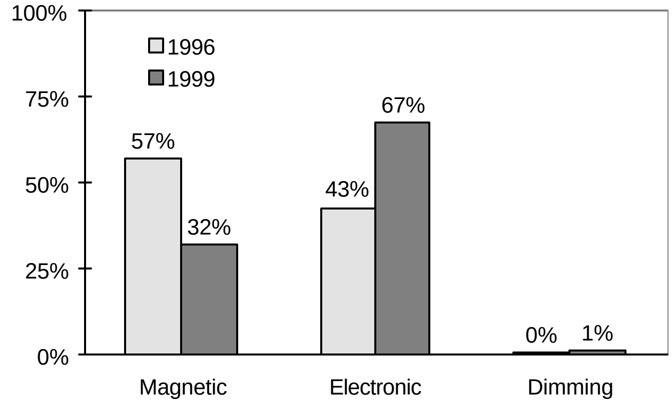


Figure 5-7
Breakdown of Linear Fluorescent Ballast Installations by Contractors, Retrospective Self Reports for 1996 and 1999

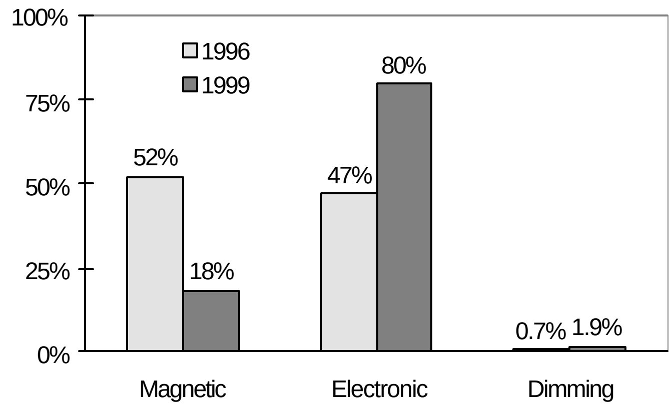


Table 5-5 presents the results of an estimate of the *annual* market penetration by type of linear fluorescent ballast type and distinguishes between new construction and all other distributor lighting sales. As shown in Table 5-4, the volume of lighting business performed by contractors is roughly evenly split between the new construction and existing construction markets. The figures calculated for the retrofit, renovation and burnout (RRB) markets in Table 5-5 are calculated such that the weighted average of the new construction penetration and the RRB penetration equals the figure we obtained from distributors for the entire market. Table 5-5 should be regarded as a rough first estimate because of the different sources used to develop the 'new construction' and 'all contractor' categories.

Table 5-5
Estimate of *Annual* Linear Fluorescent Ballast Market Penetration by Market Event

Ballast	(Ecotope) **New Constr.**	(Calculated) **Retrofit, Renov. & Burnout**	(Distributor Self-Reports) **Total Market**
Electronic	84%	50%	67%
Magnetic	14%	50%	32%
Dimming	2%	0%	1%
	100%	*100%*	*100%*

There is currently no comprehensive data source available on the *saturation*[13] of high-efficiency lighting technologies in the existing population of buildings for the entire PNW. Because it is important to understand how the saturation of high-efficiency lighting components may vary within the existing construction market, we present data from PG&E's latest commercial end user survey (CEUS) which includes 1,000 on-site surveys conducted in 1996 and 1997, as what we consider to be the best available proxy for electronic ballast and CFL saturations by building type and customer size. Efficient lighting programs have been aggressively pursued for a decade within PG&E's territory, but these CEUS data are also several years old. These two factors may combine to yield numbers that are reasonably similar to the current saturation in the Pacific Northwest. However, this is obviously conjecture and we present the data here for the purpose of discussing qualitative differences among segments.

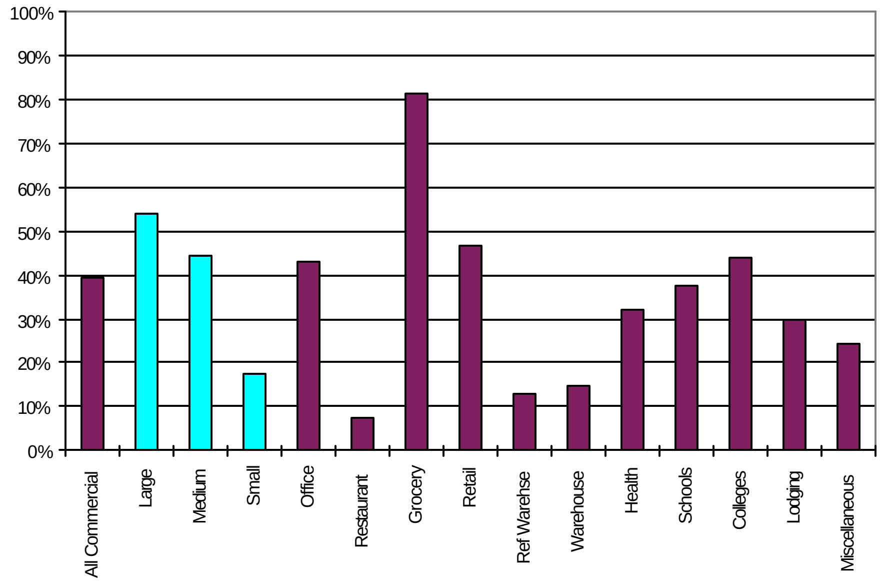
Figure 5-8 presents the saturation levels for four-foot T8 lamps and electronic ballasts in PG&E's territory, while Figure 5-9 shows data from the same PG&E study on compact fluorescent lamps (CFLs). The bars for Large, Medium, and Small show the strong correlation between the size of business and saturations of high-efficiency components. The saturations of efficient components are two

[13] Note that saturation refers to the relative market share of a technology within the existing stock of buildings, whereas penetration refers to the relative market share of a technology as a percentage of new purchases (i.e., annual sales). Annual distributor sales are composed of new purchases for both new construction and existing buildings (of course, only a small share of the total stock of lighting equipment in existing buildings is replaced each year). The saturation of high-efficiency technologies in existing construction changes more slowly than does the annual penetration.

to three times higher in medium and large facilities as they are in small organizations (under 50 kW). Despite these differences, all categories still have a

Figure 5-8
PG&E Four-Foot T8/EB Saturation

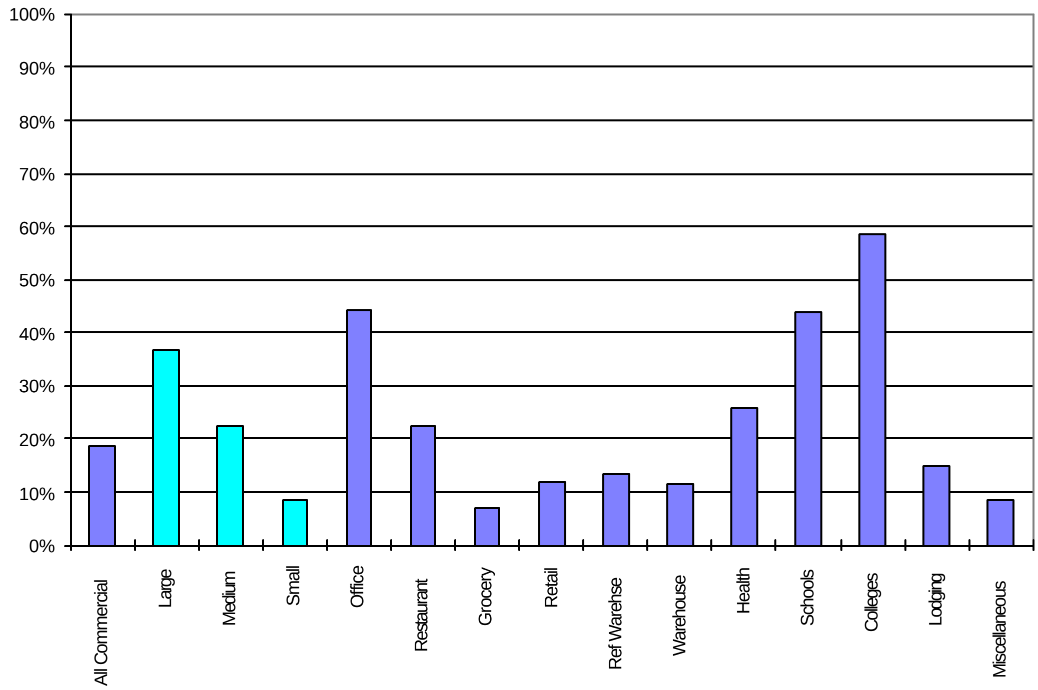
Source: PG&E CEUS. Date of Data Collection: 1996/1997



*Size is estimated based on energy consumption and full-load hours. Small < 50 kW, Medium 50 - 499 kW, Large >= 500 kW.

Figure 5-9
PG&E Commercial CFLs

Source: PG&E CEUS. Date of Data Collection: 1996/1997



*Size is estimated based on energy consumption and full-load hours. Small < 50 kW, Medium 50 - 499 kW, Large >= 500 kW.

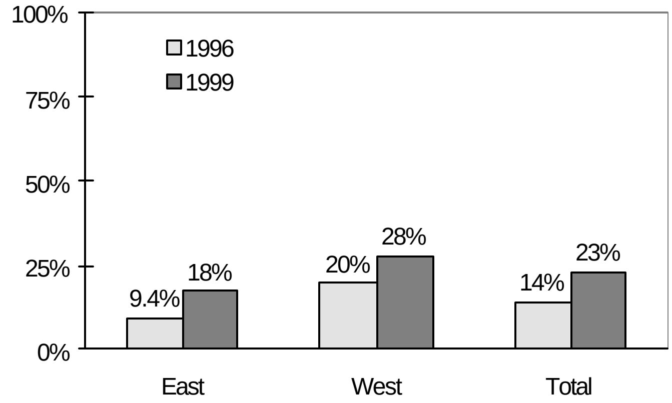
significant amount of potential for further penetration of efficient components. It is likely, however, that the naturally occurring penetration of high-efficiency components will continue to be high among the larger organizations, particularly those who practice group replacement of lamps and ballasts. Penetration among smaller organizations will likely be low without market intervention. For example, in a recent baseline study in California, only 18 percent of small customers said that they would replace their existing ballasts with electronic ballasts upon burnout of their existing magnetic ballasts.[14]

5.4.4 Occupancy Sensors

Results obtained on the percentage of projects in which contractors use occupancy sensors are presented in Figure 5-10. While the prevalence of sensors has increased over the past three years, attitudes towards the devices are not overwhelmingly enthusiastic, as they are with respect to T8 lamps, electronic ballasts and compact fluorescent lamps. Concerns about the reliability, cost of installation and basic functionality continue to abound. Perhaps it is a testament to the energy-saving potential of the technology that despite these concerns, market share is reported to have increased from about 14 percent of projects in 1996 to 23 percent in 1999. Note, however, that these figures indicate only *whether* sensors were used on a project, not how extensively.

[14] XENERGY, Inc. 2000. 1999 State-Level Small/Medium Nonresidential MA&E Study Draft Final Report. Prepared for the California Board for Energy Efficiency/Pacific Gas and Electric Company.

Figure 5-10
Percentage of Contractor Jobs with Occupancy Sensors, 1996 and 1999



5.5 Energy Efficiency Attitudes

In this section, we present responses to questions we asked about the relative importance of energy efficiency to lighting professionals businesses and the manner in which they sell such services.

5.5.1 Business Importance of Energy Efficiency

Market actors were asked how important offering energy efficient lighting products and services is to their competitive position. As shown in Table 5-6, on average, each type of market actors said that offering energy efficient lighting services is of moderate importance to their position in the market Responses from actors in western Oregon and Washington were not significantly different from those of the eastern regions of those states or in Idaho and Montana.

Table 5-6
Self-Reported Value of Offering Energy Efficient Lighting Service

[1 = Very important, 2 = Somewhat important, 3 = Not very important, 4 = Not at all important]

Actor	Rating	Obs
Distributors	1.3	56
Contractors	1.7	30
Designers	1.5	22
Average	*1.5*	*108*

Each market actor was asked about the relative importance of different considerations on lighting purchases. Distributors were asked to identify the most important factors that determine which commercial lighting equipment they recommend to their customers. The responses varied widely. Some focused on the costs and benefits of the products (17%) while others mentioned the importance of choosing appropriate lighting levels (19%) or good light quality (17%). A smaller group noted the value of easily-maintained equipment (9%) and a single respondent said that meeting code was the most significant factor in product selection.

In a similar vein, contractors were asked to think about their customers' attitudes on cost, payback, quality and maintenance. Initial cost of the equipment came out as the number one interest, with all contractors reporting this as "Important" or "Very Important" (4.4 on a scale of 1 to 5). Lifecycle costs, energy efficiency, and quality of light were considered of equal importance. Finally, ease of maintenance was reportedly only "Somewhat Important" for most of the contractors' customers.

Lighting designers were asked about the same factors as the contractors' customers, but from their own point of view. They reported significantly greater concern for the quality of light (4.4 out of 5), and significantly less for the initial cost of the equipment (3.8 out of 5).

5.5.2 Marketing "Efficiency"

Distributors were read the list of discussion topics shown in Table 5-7 and asked if they used any of them as part of their sales effort. Because of the format of the question, it was expected that most respondents would have at least a small bias toward saying "yes" to discussing the various topics. It is not surprising to find high percentages reporting discussion of several topics. It is interesting to note, however, that just 57 percent reported talking about the lifecycle costs of their products; however, 86 percent said they talked about comparative operating costs. This may indicate that some distributors are aware of the importance of economics in equipment selection but are not sophisticated enough to discuss these matters in terms of lifecycle costs; or that they simply do not see the value of framing their information in these terms.

Table 5-7
Equipment Distributor Sales Discussion Topics

Topic	Percent
Comparative operating costs	86%
Comparative lamp life and maintenance	96%
Comparative lumen depreciation	68%
Effect of quality lighting on productivity and safety	61%
Lifecycle costs / payback	57%

Contractors reported making recommendations to their clients to include "more energy efficient lighting technologies" about 80 percent of the time. This figure probably includes both cases in which the contractor recommends efficient equipment expressly wanted by the customer and cases in which the contractor recommends a lighting technology that is more efficient than the customer initially requested. Contractors recommend substituting T8 lamps for T12 lamps in about 73 percent of cases, and compact fluorescent lamps for incandescent lamps in 62 percent.

5.6 REPORTED TRENDS IN THE LIGHTING INDUSTRY

We asked contractors, designers, and distributors to describe trends in the lighting industry over the past three years and to predict the trends they though would be most significant in the next three years.

5.6.1 Past Three Years

In the case of distributors, we first asked them to tell us whether their sales of a list of ten selected lighting technologies had changed over the past three years. The results are shown in Table 5-8. Note the large percentage who report increased sales of T8s, electronic ballasts, hard-wired CFLs, and LED exit signs. Also note the large number of distributors that report that they still do not stock T5 lamps (46%) dimming electronic ballasts (33%) and linear pendant fixtures (52%).

Table 5-8
Changes in Sales Over Last Three Years

n=57	Sell Less	Sell Same	Sell More	Don't Stock	Total
T-8 lamps	4%	4%	93%	0%	100%
T-5 lamps	4%	18%	32%	46%	100%
Electronic ballasts	0%	5%	93%	2%	100%
Dimming electronic ballasts	0%	25%	42%	33%	100%
Daylighting controls	2%	41%	29%	29%	100%
Occupancy sensors	4%	32%	46%	19%	100%
Linear pendants	2%	13%	34%	52%	100%
Hardwired CFLs	5%	20%	57%	18%	100%
LED exit signs	0%	5%	82%	12%	100%
Compact MH lamps	2%	18%	60%	21%	100%

When all market actors were asked to qualitatively describe trends in the lighting industry over the past three years, a number of patterns emerged. Key trends included:

- T8 lamps and electronic ballasts are now standard practice.
- Much more attention is paid to comfort and productivity.
- Compact fluorescent lamps have become much more common.
- T5 lamps have emerged from obscurity (still very little use, but lots of interest/awareness).
- Utility rebates were significantly reduced.
- Use of pulse-start metal halide fixtures is increasing.

Respondents reported that standard practice had changed with respect to increasing acceptance of compact fluorescent lamps and dominance of the T8 lamp / electronic ballast combination. Market actors also talked about changes in codes, increasing numbers of daylighting projects and the increasing use of indirect/direct fixtures. Niche innovations such as the use of MR-16s in restaurants and light emitting diodes (LED) in exit signs were also noted.

In addition, contractors in Idaho and Montana stated that the pace of change in the industry had increased. Businesses are selling and purchasing smaller quantities of equipment more frequently, they say, meaning more and smaller jobs for all the lighting professionals. Also, manufacturers representatives change product lines quickly, and often change the manufacturers they represent as well.

5.6.2 Predictions for the Next Three Years

Contractors, distributors and designers were also asked to describe the changes the believed would occur over the next three years. Comments ranged widely from the maturing of the fusion lamp to fiber optic light delivery and white LEDs as light sources. Common predictions were:

- T5 lamp will increase market share in mainstream applications.
- Dimming ballast usage will increase in conjunction with more daylighting design.
- Movement toward fast design-build projects with modular lighting designs.
- Improvements to existing dimming systems and occupancy sensors are expected to substantially quell existing concerns with these technologies.
- More fixture choices for efficient lamp and ballast configurations will be marketed.
- One designer mentioned that Seattle now requires Leadership in Energy and Environmental Design (LEED) certification for its city buildings, and felt this could set a precedent that other cities might follow.

5.7 EGIONAL LIGHTING PRACTICES

This section presents results on a series of questions asked about design and specification practices, particularly with respect to the use of daylighting, among designers, distributors and contractors.

5.7.1 Daylighting Design Practice

Interest in daylighting is rapidly increasing and, while market activity lags behind interest, there is value in investigating the practices of professionals who are actively promoting and working on daylighting projects. In this section, we first look at the prevalence of daylighting projects in the Pacific Northwest, then the knowledge levels and attitudes of the region's lighting professionals, and finally present the barriers to increased implementation.

Prevalence

Distributors, contractors, and designers were in rough agreement over the percentage of new projects with daylighting. Distributors reported 6 percent of recent projects for which they supplied equipment included daylighting controls or dimming ballasts. Contractors said they installed daylighting systems in about 4 percent of their recent projects. Designers reported that the percentage of customers requesting daylit buildings was slightly less than 3 percent. Designers also reported that the percentage was higher west of the Cascades than east. Western designers reported 4 percent of their clients had directly requested that daylighting be included on their project, while eastern designers said the number was closer to 1 percent for them.

Designers were also asked how often they participated in lighting projects early enough to influence the design process toward daylighting. As shown in Table 5-9, only 8 percent said they were "often" involved at an early enough stage, while 24 percent reported they were "sometimes" involved early enough.

Table 5-9
Frequency of Early Participation of Designers in Daylighting Design

	East	West	All
# Respondents	10	15	25
Often	0%	13%	8%
Sometimes	10%	33%	24%
Rarely	30%	20%	24%
Never	60%	33%	44%
Totals	*100%*	*100%*	*100%*

Knowledge

Designers were asked to rate their knowledge of particular areas of daylighting: building siting, fenestration design and specification, calculations and analysis, and specification of electric lighting controls for integration with daylighting systems. In both east and west regions, results were very similar for all categories. As shown in Table 5-10, average ratings were between 'not very familiar' and 'somewhat familiar'. Some designers use engineers for their specifications of electric lighting controls, which raised the overall average on controls systems, but results were still below a basic understanding level. No one reported having expert knowledge of daylighting.

Table 5-10
Designers Self-Rated Familiarity with Aspects of Daylighting
(1 to 5 where 1 means completely unfamiliar and 5 means expert)

	East	West	All
Building Siting for Daylighting	2.2	2.2	2.2
Fenestration Design and Specification	2.3	2.4	2.4
Calculations and Analysis	2.3	2.2	2.3
Specification of electric lighting controls for integration with daylighting systems	2.7	2.6	2.6
# Respondents	11	14	25

Designers and distributors were also asked to describe the benefits of daylighting. As shown in Table 5-11, respondents developed a reasonably comprehensive list in aggregate, but individual respondents were hard-pressed to list more than two or three benefits. Most commonly cited was the energy savings potential. Next came increased occupant satisfaction, increased building value and productivity. These latter non-energy benefits appear to be under appreciated by the designer community.

Table 5-11
Similarity in Reported Daylighting Benefits

Factor	Designers	Distributors
# Respondents	29	31
Improved productivity/performance	31%	19%
Increased Sales (Retail)	11%	3%
Increased Occupant Satisfaction	44%	35%
Reduced Energy Costs	88%	84%
Increased Building Valuation	33%	6%
Reduced Eye Strain	11%	10%
No benefits	3%	0%

Attitudes

Designers were asked if they actively pursue daylighting design as part of their business strategy. Responses were different in the east and west, with more daylighting practices reported to be already in place in the west. Figure 5-10 and 5-11 show the status for daylighting action. The percentage saying they actively pursue daylighting clearly far exceeds the volume of daylighting projects being implemented, according to designers own self reports. Thus, these results should be viewed as more indicative of designers intent rather than their actual actions.

Figure 5-11
Designer Pursuit of Daylighting
Western Region

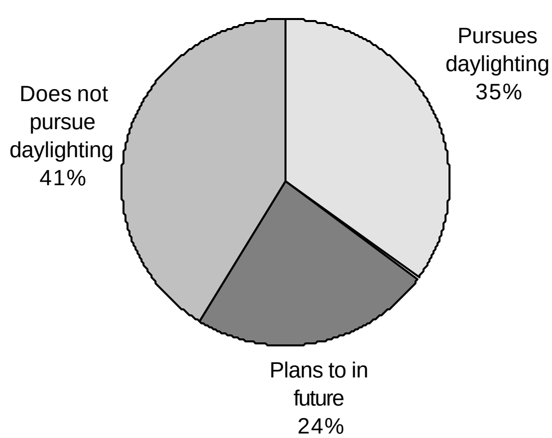
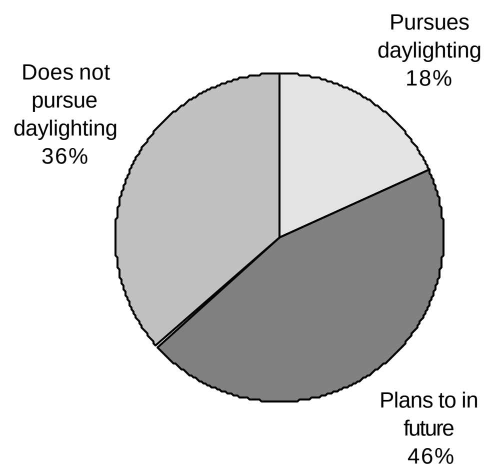


Figure 5-12
Designer Pursuit of Daylighting
Eastern Region



Both contractors and designers reported being “somewhat” to “very” interested in increasing the amount of daylighting work they do. This was true for most respondents, including those who had some prior experience with daylighting and those with none.

Of the designers interviewed, 80 percent said that they believed daylighting *could* play a more significant role in lighting commercial and industrial buildings. When asked where and how this could be so, some responses were:

- "Industrial and large retail superstores could use daylighting much more. Skylights can give a lot of light in superstores, and increase sales. Productivity is increased in institutional applications."
- "Daylighting will increase as the need to reduce energy costs rises. Also, companies will use daylighting to attract employees."

Of the remaining 20 percent of respondents, half said daylighting *would not* play a significant role in the future of nonresidential buildings, and the other half were unsure.

Barriers

We also asked designers, contractors and distributors whether there were any reasons they would recommend *against* using daylighting in new construction projects. Reasons cited included concerns over equipment reliability, heat loss/gain, the potential for maintenance problems, and a belief that codes are easier to meet without the trade-offs associated with daylighting. The five most common responses were:

- Higher first cost (from added design work and materials)
- Lack of owner/developer awareness or interest
- Additional project development time
- Limited designer knowledge of daylighting
- Inappropriate for building type/usage (glare, degradation of materials)

Daylighting Mini-Interviews

The respondents to the four daylighting-only surveys described in Section 4 were much more savvy to daylighting than our designer population as a whole. The architects interviewed for this short survey ranked themselves consistently higher when it came to their knowledge of daylighting. Knowledge of building siting considerations for daylighting were rated a 4 out of 5 (where 5 means expert). Fenestration design and specification seemed to be the low point for this sample, with the architects reporting slightly better than a basic understanding of fenestration systems. Calculation and analysis of daylighting designs were rated as being better understood than the larger pool of designers, with these respondents having a good understanding. All of the responding architects said that their knowledge of lighting controls was expert level due to the fact that they use excellent outside consultants for specifying integrated control systems. Despite the self-reported knowledge, none of the architects in this sample have developed specifications for integrated lighting controls themselves.

These architects mentioned the familiar reasons daylighting is a benefit, such as energy savings and comfort. Two reasons emerged that were not mentioned by others in the study:

- Light quality and environmental quality are improved

- Psychological benefits associated with natural light and being able to see outside (a connection to exterior)

The architects offered reasons why daylighting may not be appropriate in all building types. Besides the fragmentation of specialties and integration problems, they mentioned the difficulty of getting light into the interior spaces of large buildings. One noted that sunlight may not be suitable in certain areas, but did not elaborate.

All respondents said that they include engineers, developers and owners early in the design process for daylight integration. Respondents in this small sample also said that they have provided daylighting controls and/or dimming ballasts on an average of 71 percent of their projects in the past 2 years. One respondent even said, "Our goal is 100 percent, but realistically about 80 percent get included”.

5.7.2 Modeling/Simulation Tools

Another target area of our surveys dealt with whether designers use tools as part of the lighting design process. Table 5-12 shows the frequency with which designers use the various tools to help layout fixtures and determine appropriate densities. The tools listed include hand calculations, IES manuals, paper or computer templates, and computer models of diverse complexity. Hand calculations and rules-of-thumb were by far cited as being used most often by designers. Designers said they use computer modeling in only about 45 percent of jobs. Popular computer simulations and models were programs such as Visual, AutoCAD, Lumen Micro, LightPro, AGI, and Radiance. While these computer tools have gained prominence in recent years, manufacturers’ guidelines, point-by-point hand calculations and basic rules of thumb are still the staples of most designer’s toolkits.

Table 5-12
Use of Design Tools in Commercial Lighting Design
[Often=1, Sometimes=2, Rarely=3, Never=4]

	East	West	All
Hand calcs and rules-of-thumb	1.0	1.3	1.2
IES Reference Manuals	1.5	1.7	1.6
Room Cavity Modeling	2.1	2.5	2.3
Manuf/In-house Layout Templates	2.9	3.2	3.0
Radiosity Computer Models	3.8	2.6	3.1
Ray-tracing Computer Modeling	3.1	3.2	3.2
# Respondents	12	16	28

5.7.3 Specification

Equipment is specified by a number of market actors. Of distributors, 61 percent said they offer equipment specification services, although all will supply detailed equipment recommendations written in a format that can be used for specifications. Distributors reported specifying 35 percent of all the equipment they sell. Perhaps surprisingly, 70 percent of contractors offer design and specification services in the western region, this number increases to 92 percent in the eastern Region. In addition, contractors actually specify equipment on about a third of their jobs.

All the respondents were asked for the percentage of commercial lighting projects on which they have discretion over the kind of equipment specified. Designers, consisting of electrical engineers, lighting specialists and architects, said they have discretion on about 74 percent of jobs. Contractors said 33 percent and distributors 35 percent. Possible explanation for the reason why these sum to more than 100 percent are that: 1) designers are only involved in a portion of the total lighting jobs performed; and 2) contractors and distributors likely have included cases where they make major revisions to specifications provided by the designers.

Nearly every lighting designer mentioned that they use Illuminating Engineering Society (IES) guidelines to help them pick appropriate illuminance levels and fixture densities in preparation for specifying. Meeting code requirements was mentioned by a couple of distributor firms as a key factor as well. Once the illuminance levels are chosen, there are a number of factors considered when selecting the specific equipment configurations and types. Distributors sorted a list of factors in descending order of importance:

- Initial cost of the equipment,
- Lighting level (appropriate brightness),
- Lighting quality (color, effect on look of merchandise),
- Total lifecycle costs / energy efficiency, and
- Ease of lamp replacement, maintenance.

Designers had the same list but with ‘Lighting Quality’ at the top and with ‘Total Lifecycle Costs’ ranked second in importance. Issues such as the flexibility in the initial configuration and the ease of reusing or relocating the equipment were not mentioned by anyone.

Influence

Table 5-13 lists the specific market actors designers identified as having influence over the specification of lighting equipment. Electrical engineers and lighting designers featured prominently in both regions but not equally. In the east, electrical engineers were said to have a majority of the influence over lighting equipment specification, while specialty lighting designers accounted for about a quarter. In the west, lighting designers reportedly have slightly more influence over specification than engineers. This greater use of lighting specialists west of the Cascades was seen throughout our surveys.

Table 5-13
Who Has Influence Over Specification?
As Reported by Designers

	East	West	All
Electrical Engineer	58%	33%	43%
Lighting Designer	25%	39%	33%
Architect	8%	17%	13%
Owner	0%	11%	7%
Developer	8%	0%	3%
Tenant	0%	0%	0%
General Contractor	0%	0%	0%
Other	0%	0%	0%
Totals	*100%*	*100%*	*100%*
# Respondents	12	18	30

When asked about who has influence over the fixture layout, the answers were similar, with electrical engineers having the bulk of the influence in the east and comparable influence with lighting designers in the west. (See Table 5-14.)

Table 5-14
Who Has Influence Over Fixture Layout?
As Reported by Designers

	East	West	All
Electrical Engineer	70%	40%	50%
Lighting Designer	20%	30%	27%
Architect	0%	25%	17%
Developer	10%	5%	7%
Owner	0%	0%	0%
Tenant	0%	0%	0%
General Contractor	0%	0%	0%
Other	0%	0%	0%
Totals	100%	100%	100%
# Respondents	10	18	28

The responses changed somewhat when designers were asked to identify who has influence over the choice to use lighting controls and the types of controls installed. Electrical engineers are still most influential, but owners play a larger role than with fixture equipment and layout. Designers reported that their own firms have primary responsibility for specifying lighting controls on 65 percent of jobs. Table 5-15 shows the designer responses when asked about characteristics of the whole market.

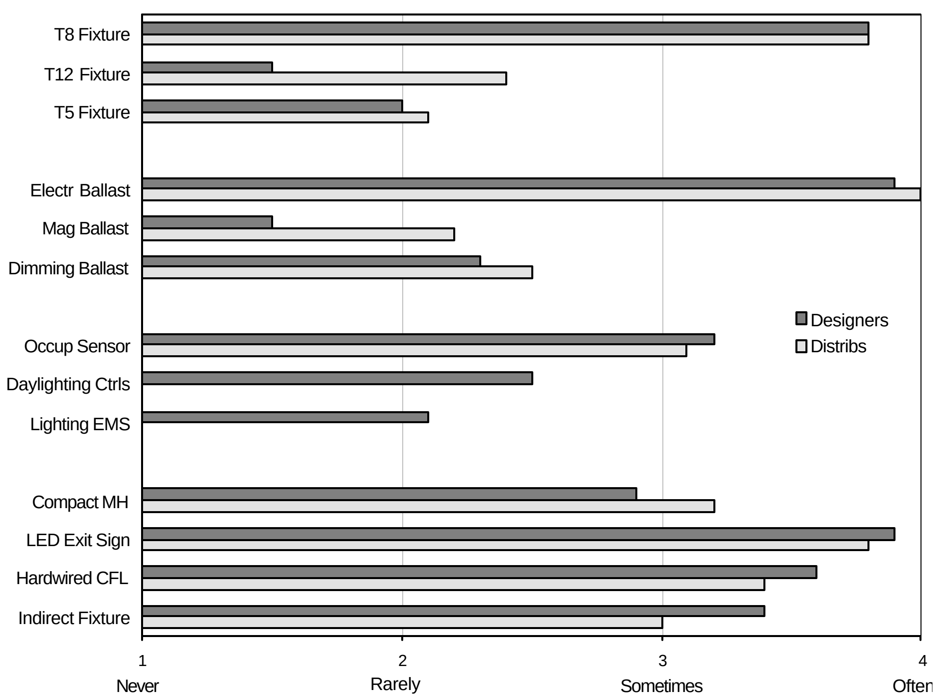
Table 5-15
Who Has Influence Over Use and Types of Lighting Controls?
As Reported by Designers

	East	West	All
Electrical Engineer	67%	55%	59%
Owner	17%	14%	15%
Lighting Designer	8%	14%	12%
Architect	8%	14%	12%
Other	0%	5%	3%
Developer	0%	0%	0%
Tenant	0%	0%	0%
General Contractor	0%	0%	0%
Totals	100%	100%	100%
# Respondents	11	18	29

Frequency

Distributors and designers were asked how often they specify certain lighting equipment. As illustrated in Figure 5-13, respondents were most likely to say they "Often" specify T8 lamps, electronic ballasts, and LED exit signs. Hardwired compact fluorescent lamps, indirect and indirect/direct fixtures, compact metal halide lamps and occupancy sensors were in the second tier of responses, with most saying they specified these products "sometimes." T12 and T5 lamps, magnetic and dimming ballasts, daylighting controls and lighting energy management systems fell between "rarely" and "sometimes".

Figure 5-13
Frequency of Equipment Specification



According to these qualitative results, T5 lamps are specified more frequently by designers than T12 lamps. However, our sales figures show that many fewer T5 lamps are sold. This discrepancy may be due to the strong desire expressed by designers to use T5 lamps more frequently, and may also indicate that distributors are more likely to be involved with replacement and repair where technology changes are not appropriate. For the same reason, we note that T12 lamps are specified more often by distributors than by designers.

Barriers

Occupancy sensors have received mixed reviews in recent years due to their terrific success at saving energy in some situations and abysmal failure to provide functional service in others. To learn more about attitudes toward occupancy sensors and gain insight into the pressing barriers to further use of the technology, we asked survey respondents the reason(s) they would not recommend using sensors. Table 5-16 shows the top four responses for each of the lighting market actors, with the most frequently cited reasons at the top.

Table 5-16
Reasons for Not Recommending Occupancy Sensors

Distributors	Contractors	Designers
First cost (incl. Installation)	First cost	First cost
Lack of knowledge by designers	Equipment reliability	Equipment reliability
Customer's override/misuse	Maintenance problems	Commissioning/re-tuning costs
Power too cheap to justify	Customer override/misuse	Maintenance problems

After citing first cost, it is apparent that designers and contractors blame the equipment and the distributors blame the designers. However, there are several other important factors. The equipment has been made quite complex and lacks easy installation. Designers may not be providing sufficient instructions for contractors who don't want to waste time getting training. Also, the contractors may not want to adjust the sensors repeatedly, despite the current need for that arising from occupant tampering. Finally, the occupants would be less likely to tamper with the sensors if their functionality was transparent.

Changes in Specification

Designers and distributors said that occasionally the installed lighting equipment differs from the original specification. Table 5-17 shows the reasons offered by contractors for these changes. By far the most common reasons given were finding a product considered equivalent for a better price, and lack of availability for the originally specified product. Respondents explained that a product is "unavailable" if it cannot be purchased at a reasonable price from the main electrical supplier for the project or from another supplier the contractor has a close relationship with.

Table 5-17
Reasons for Equipment Substitutions by Contractors

Reasons	East	West	All
Found better price	50%	37%	43%
Not available	30%	37%	34%
Used better quality	5%	11%	9%
Use better brand	0%	11%	6%
Poor original design	10%	4%	6%
Past relationship with supplier	5%	0%	2%
Total	*100%*	*100%*	*100%*

Contractors in the east said that nearly a third of the time architects or owners allow substitutions from the original equipment specification. Western region contractors reported a much higher substitution rate, at 65 percent.

5.8 INFORMATION SOURCES, INTERNET USE, LIGHTING LAB AWARENESS/USE

Understanding where lighting professionals obtain information was also a focus of the Study. Two-thirds of distributors reportedly rely on manufacturers to keep them current on new technologies, while almost half subscribe to trade magazines. One quarter attend trade shows such as Light Fair. About 65 percent of designers get information on new lighting products from manufacturers, 46 percent from trade magazines, and a quarter use the Internet or attend trade shows. Contractors are a bit different in that 70 percent get information from trade magazines, 44 percent from manufacturers and 33 percent from distributors. The usage of the Internet for information on new products is limited across all actors, but is especially limited among distributors and contractors.

Table 5-18
Source of Information on New Lighting Technologies

Source	Distributors	Designers	Contractors
Colleagues in same profession	5%	12%	0%
Distributors	13%	12%	33%
Manufacturers	66%	65%	44%
Trade magazines	45%	46%	70%
Websites	5%	23%	4%
Trade shows (e.g., Lightfair)	25%	27%	11%
Northwest Lighting Lab	14%	8%	7%
PGE Lighting Lab	2%	0%	0%
# Respondents	*56*	*26*	*27*

Three out of four distributors are aware of the Lighting Design Lab (LDL) in Seattle, and 47 percent have visited—mostly to attend classes, use the mock-up facilities or go on tours of the facility. Eightyone percent of designers are aware of the LDL, and 42 percent have visited the lab as well. Designers have utilized the widest variety of services at the lab, from attending classes, to using daylight simulations and mock-up facilities. Thirty-three percent of designers attended LDL Road Shows as well. Contractors' familiarity with the Lab is below designers and distributors, at around 59 percent. Thirty-nine percent of all contractors reported having visited the Lab, however, mostly for classes.

Table 5-19
Awareness and Use of the Lighting Design Lab in Seattle

		Aware	Visited	Used Services
Distributors	*n=57*	75%	47%	49%
Contractors	*n=29*	59%	39%	87%
Designers	*n=26*	81%	42%	53%

Table 5-20
Lighting Design Lab Services Used

	Distributors	Contractors	Designers
Consultations	5%	25%	22%
Mock-up facilities	23%	17%	22%
Classes	45%	50%	56%
Tours	18%	0%	22%
Daylighting simulations	0%	17%	22%
Attended Roadshow	0%	33%	22%
Other	9%	0%	22%
# Respondents	*22*	*12*	*9*

Professionals in all areas use the Internet and World Wide Web for business purposes. Only 3 percent of contractors in the Pacific Northwest have ever purchased lighting equipment for a job through the Internet. One respondent said, "we've been looking into [buying from the Internet], but local purchasing is better for managing jobs". Others say they use the Internet to study products and trends, but not to purchase equipment. Several respondents felt that agreement that Internet purchasing may be viable in the future, however.

As for the use of www.lightsearch.com, very few contractors (7%) have ever visited the site. Only half of those had ever used services from the website. Distributors had a better knowledge of the site, as 42 percent had visited. A third of all designers had also visited www.lightsearch.com. A quarter of responding distributors and designers reported using services from the website.

Table 5-21
Use of the Website www.lightsearch.com

		Visited	Used Services
Distributors	*n=57*	42%	25%
Contractors	*n=30*	7%	3%
Designers	*n=24*	33%	25%

5.9 INTERVIEWEE SUGGESTIONS

At the end of each interview, respondents were asked whether they had suggestions for initiatives that the Alliance should consider. The majority of responses were in the area of education, followed by rebates, code issues and advertising. The most frequent suggestion was for the education of market actors who are in charge of specifying or requesting energy efficient technologies and practices. Most respondents said that products and practices with efficiencies greater than typical (such as daylighting) are misunderstood by those who specify and build in the Pacific Northwest. Many respondents believe that, in order to increase demand of these services, more information and education is needed. Specific suggestions included:

- Educate or train architects, designers, owners, developers and engineers
- Offer continuing education credits for classes attended by students
- Require lighting training for professionals who participate in projects receiving incentives
- Hold seminars, conferences and trade shows (for small and large cities)

Many participants raised issue of energy codes (or the lack thereof). More common in the eastern region were comments regarding the lack of enforcement of existing energy codes. Some also mentioned the idea of offering incentives on projects that performed better than code.

Rebates or incentives were mentioned by both designers and contractors. There were slight differences among the populations, but overall, rebates or incentives were less important to those surveyed than education and codes. One contractor from the western region differed from most of the rest, noting that: "Rebates work because equipment costs too much. Training is not too important for us because we can wire anything…getting it specified is the problem." Another less-common mention was in the area of information dissemination. Some suggestions were to:

- Promote case studies
- Promote new products to specifiers and contractors
- Advertise existing utility incentive programs better

Other comments included:

- Mandate changeout of all T12 lamps in government buildings
- Don't involve utilities
- Do away with codes; make it easier to design what clients want

6 PROMISING TECHNOLOGIES AND PRACTICES

6.1 SUMMARY OF OPPORTUNITIES

This chapter summarizes the opportunities and technical barriers associated with lighting technologies and practices that have potential to impact the energy efficiency market in the Northwest. Section 6.2 introduces the "top ten" most promising technologies and practices. In Section 6.3, we present an analysis of the total region-wide lighting savings that could be obtained from these technologies and practices. Section 6.4 continues with technologies that are still in development and are not yet viable or are widely publicized but not proven. The first-tier technologies and practices discussed in this section are as follows:

- Energy effective lighting design (non-daylighting)
- Daylighting by design
- Fluorescent dimming
- Integrated lighting controls
- Halogen IR sources
- High efficiency generic fluorescent fixtures
- T5 and T5HO fluorescent luminaires
- Modern metal halide lamp/ballast systems
- Modern industrial fluorescent systems
- High efficiency compact fluorescent luminaires

Table 6-1 provides an overview of our assessment of the most promising technologies and practices. Each of these technologies and practices is discussed in detail in Section 6.2.

Table 0-1
Overview of Promising Technologies and Practices

					Y = YES, N = NO, S = SOME				
RANKING	TECHNOLOGY/PRACTICE	CURRENT TECHNOLOGY STATUS E= Experimental B = Basic Proven A = Advanced Proven	CURRENT BODY OF KNOWLEDGE STATUS E = Experimental B = Basic A = Advanced H = Highly Evolved	CURRENT MARKET ACCEPTANCE NA = Not Commercially Avail. HR = High Risk Adapters E = Early Market Adapters SP = Standard Practice	Proven Energy Savings	Multiple Manufacturers	Proven Reliability	Relatively Expensive First Cost (to Standard Practice)	Common Understanding of Value/Opportunity
1	ENERGY EFFECTIVE LIGHTING DESIGN	A	E,B,A,H	E	Y	NA	S	S	S
2	DAYLIGHTING BY DESIGN	A	E,B,A,H	E	Y	NA	Y	Y	S
3	FLUORESCENT DIMMING	E, A	A,H	E	Y	Y	S	Y	N
4	INTEGRATED LIGHTING CONTROLS	E, B	B,A	HR	Y	Y	S	Y	N
5	HALOGEN IR SOURCES	A	A	E	Y	Y	Y	Y	S
6	HIGH EFFICIENCY GENERIC FLUORESCENT FIXTURES	A	A,H	E	Y	Y	Y	S	S
7	T5 AND T5HO FLUORESCENT LUMINAIRES	A	A	E	Y	Y	S	Y	S
8	MODERN METAL HALIDE LAMP/BALLAST SYSTEMS	E, A	A,H	E	Y	Y	Y	S	S
9	MODERN INDUSTRIAL FLUORESCENT SYSTEMS	A	A,H	E	Y	Y	Y	S	S
10	HIGH EFFICIENCY COMPACT FLUORESCENT LUMINAIRES	A	A	E	Y	Y	Y	S	S

6.2 FIRST TIER TECHNOLOGIES AND PRACTICES

In Section 6.2.1 we present a list of the top ten technologies and practices for consideration in the Pacific Northwest. These are identified as the most promising areas for lighting efficiency improvements in the existing market. The technologies have been identified and analyzed as to their applications, benefits, cost effectiveness, and penetration/acceptance in the market. Major barriers to current and future usage are also included.

6.2.1 Energy Effective Lighting Design (Non-Daylighting)

TECHNOLOGY/ PRACTICE

Energy effective lighting design optimizes the systems' performance rather than individual component performance. Some of the measures include:

- separating ambient and task lighting into component layers
- using high efficiency luminaires having a high coefficient of utilization for the application
- meeting current IESNA illuminance recommendations, eliminating overlighting
- developing and meeting an appropriate energy budget
- differentiating between power use and energy use and developing designs that strategically minimize both
- using high efficacy light sources based on mean (maintained) lumens per watt
- optimizing room finishes and geometry to improve utilization of light
- matching the control system profile to lighting needs and usage
- using light sources with spectra that enhance visibility

APPLICATIONS

Most industrial, commercial, and institutional lighting applications

BENEFITS

Optimized design practice delivers the required lighting (quantity and quality) in the most efficient manner possible. Application driven design maximizes system efficiency by specifying the most appropriate luminaire distribution, lamping/ballasting, control(s), and layout given the application, space, task, and user. Taking full practical advantage of economic, energy effective lighting design strategies can save at least 20% of the energy use of that consumed by a conventional lighting system. Some examples of energy effective lighting benefits are:

- Increased illumination per generated lumen
- Increased visibility per foot-candle, reducing complaints and other concerns related to a minimum energy use design
- Helping prevent a variety of less-than-optimal practices encouraged by some energy codes
- Assuring that controls reduce operating time and power to the absolute minimum required by the task.
- Reduces general ambient lighting levels since task areas generally constitute only a portion of space being illuminated - saving energy

COST EFFECTIVENESS

Dependent on design. Potentially very high. The cost of cookie-cutter lighting designs for C&I projects commonly runs about 2.5% of the cost of the installed lighting system. The extra effort required to turn this into an energy effective lighting design could increase this to 5%.

Requires appropriate design, equipment and controls. Can provide high energy savings, especially when daylighting is one of the components.

Depending on the lighting system, can reduce energy use by 10-50%, e.g., for indirect lighting systems, every 1% increase in ceiling reflectivity can deliver comparable lighting levels using 1% less power.

ACCEPTANCE PENETRATION

Most installations are designed to meet code, but not optimized for the application. Lighting quality may suffer and, often, the lighting design demands more power/energy than necessary. Few lighting practitioners have mastered energy effective lighting design beyond those elements required by code.

- Most basic designs are developed according to de facto standards of the marketplace - little value is placed on creative solutions, efficient or not.
- Most designers are unaware of the benefits of using the most current standards, published in the IESNA Handbook 2000 (Ninth Edition), which depart from previous recommendations in two significant ways: 1) illuminance recommendations are given as averages not minimums and 2) it underscores the fact that ambient lighting levels can be a third to one-half that for task lighting levels.
- Most energy codes confuse or overwhelm designers. Target energy levels by room are seldom used.
- Power-oriented energy calculations are relatively easy to

analyze since time of use is not considered; energy-oriented calculations however are dynamic and require greater effort and expertise to analyze.

BARRIERS Lack of expertise, lack of tools, additional cost. Most lighting specified by people indifferent to energy concerns. Lighting industry is cautious to accept spectrum-based visibility because of industry politics and fear of liability. Applications personnel are only slightly aware of the issue.

SOURCES Advanced Lighting Design Guidelines, 2000

Presentation, *"Energy efficient versus energy effective lighting",* LightFair International, May, 2000 New York

Advanced Lighting Guidelines 2000, second review draft, various authors

Lighting Technology Atlas, E Source, 1997

6.2.2 Daylighting By Design

TECHNOLOGY/ PRACTICE Designing buildings to improve or maximize the amount of space that can effectively be illuminated by daylight. Providing appropriate electric lighting and controls, and in some cases, mechanical daylighting controls such as blinds. Some of the measures include:

- *Optimized Basic Building Design*. Includes a combination of building siting, solar orientation, and building massing for appropriate heating/cooling characteristics with daylighting.
- *Optimized Basic Fenestration Design.* Includes size and orientation of windows, type of glazing, passive shading, and related considerations.
- *Optimized Advanced Fenestration Design.* Includes skylights, clerestories, light shelves, and similar concepts.
- *Daylighting controls*. Mechanical and electric.

APPLICATIONS All day-use buildings where general illumination is required.

BENEFITS The ultimate renewable resource. Most people prefer working, shopping, and socializing in daylit spaces. Potential exists to provide up to 80% of lighting needs during daylight hours in daylit optimized spaces. Maximizes daylight distribution while minimizing glare. Creates comfortable visual environment.

Daylighting design can permit a wide range (75% to 300%) of the target lighting level without requiring supplemental electric light and not adding to HVAC load as compared to electric light. The greatest daylighting is usually realized during peak demand periods (mid day), saving the most expensive electricity.

High energy payback and "productivity" payback in worker-intensive areas benefiting from daylighting.

- For basic building design, long buildings with the major facades on the north and south sides tend to be optimum; buildings with major east and west facades tend to be very challenging.
- Basic fenestration design prevents excessive solar gain and provides views and daylight for perimeter spaces (penetrates into the space up to twice the window height)
- Advanced fenestration introduces daylight deeper into a space, increasing the percentage of space being daylit.
- Mechanical and electric controls ensure the correct harvesting of daylight. They work by preventing unnecessary energy use for electric lighting or HVAC.

COST EFFECTIVENESS

Highly variable. High if properly designed, low otherwise.

ACCEPTANCE PENETRATION

Rarely practiced. While in general architects believe that daylighting is desirable, practical concerns including site constraints and cost typically outweigh daylighting. Few designers, even "green" ones, have the necessary experience and skills to maximize daylighting in buildings while creating comfortable visual and thermal environments practically and cost-effectively. Many "daylit" buildings demonstrate that daylit buildings don't work; they are failures because the visual environment is not comfortable --they are too glarey, and/or they are not thermally comfortable, running too hot or cold.

BARRIERS

First cost, low payback in PNW, and lack of technical skill among architects, engineers and contractors. Most commercial real estate is designed around a "real estate model" not an "energy model" with the objective to maximize building square footage on site disregarding solar orientation and massing, to build densely-packed buildings with high reflectivity glazing (low light transmission) and high mass walls with windows added for views, not daylighting. Most new large commercial building projects (where energy impacts are the greatest) are primarily concerned with the "look", not the embedded or operating cost.

Low energy costs in NW and increasing land costs place a real-estate driven premium on square footage of any type. The lack of evidence to support productivity and health benefits prevents good daylighting from being designed for all but a handful of wealthy or especially concerned groups.

SOURCES

Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance, August 1997, Heschong Mahone Group

Skylighting and Retail Sales: An Investigation into the Relationship Between Daylighting and Retail Sales, August 1999, Heschong Mahone Group

Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

Skylighting Guidelines –Energy Design Resources, Southern California Edison

6.2.3 Fluorescent Dimming

TECHNOLOGY/ PRACTICE

Use of electronic dimming ballasts in fluorescent and compact fluorescent lighting systems provides ability to control fluorescent and compact fluorescent lighting in response to occupant demand and daylight availability. Technologies include:

- Electronic dimming ballasts for T8 lamps
- Electronic dimming ballasts for CFLs and T5 twin tube lamps
- Electronic dimming ballasts for T5 linear lamps
- Dimming devices and interfaces

APPLICATIONS

Offices, retail spaces and educational institutions.

- Ambient and task lighting in offices.
- For retail, “big-box,” department stores and mall cores with skylights, single story strip, etc.

- Education: classrooms, mixed media use, etc.

BENEFITS

In concert with integrated controls, this represents the single greatest technology building block to reduce lighting power demand and energy consumption in the Northwest. On average, dimming can harvest the equivalent of around 50 percent of the total lighting load all of the time, which is equivalent to 50 percent energy savings for the affected zones. The floorspace available for daylighting is significant. We estimate that approximately 40 percent of existing construction floorspace is within 15 feet of an exterior wall. However, because window areas are not adequate in all perimeter spaces, the floorspace feasible for conversion may be closer to 25 percent. A recent study estimated that up to 60 percent of existing floorspace may directly under a roof; however, the feasible floorspace for skylights is likely to be well below that figure due to roof structures (especially, HVAC equipment) and existing skylights.

COST EFFECTIVENESS

Depending on the application, effectiveness can range from modest to very good. Dimming controls add at least $20 per installed lamp to any lighting system.

ACCEPTANCE PENETRATION

Technology is only being specified for higher-end, specialized applications, e.g., conference rooms, audio visual spaces, computer intensive environments, energy demonstration projects, etc. Less than 1% applicable new specifications, therefore, less than 1% market penetration. Dimming ballasts constitute about 3% of electronic ballast sales; typically used for architectural dimming, rarely for energy savings.

Even in buildings with appropriate daylighting design, electrical design seldom provides lighting controls to harvest the daylight, usually due to first cost limits.

BARRIERS

Electronic dimming ballasts cost two-and-a-half to five times more than standard, non-dimming T8 electronic ballasts. Confusing interfaces and lack of dimming controls, limited availability (i.e., not "stock" items). Need standardization and consolidation of product offerings and mass production to bring prices down and launch dimming technology into mainstream. Color shift of lamps when dimmed not acceptable in some applications.

SOURCES

Rundquist, et al, *Lighting Controls: Patterns for Design*, EPRI 1997
Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

Manufacturer's literature from the following companies: Lutron, Advance, Energy Savings Inc., Wattstopper, Electronic Lighting Inc., Lightolier, OSRAM SYLVANIA

6.2.4 Integrated Lighting Controls

TECHNOLOGY/ PRACTICE

Automatic dimming and/or turning off of lights when they are not needed. Combines some or all of the following controls:

- *Tuning Controls*. Sets highest allowedlight level (high trim) - can go up to equipment maximum
- *Dimming Controls*. Sets current light level
- *Daylighting*. Automatically reduces electric light when adequate daylight is available
- *Lumen Maintenance Controls*. Automatically increases lighting power to compensate for lumen depreciation over time
- *Scheduling (predictable) Controls*. Turns lights on when needed according to a fixed schedule. Can be based on clock (time of day) or solar schedule (sunrise/set)
- *Scheduling (not predictable) Controls*. Turns lights on when needed according to a varying schedule. Generally based on occupancy. Most commonly accomplished with stand alone occupancy sensors
- *Adaptation Compensation Controls*. Increases interior lighting during the day in areas not illuminated by daylight but needing light to allow comfortable transitions between areas with daylight and areas without. Just as it is difficult to see when driving into a tunnel in the daytime because of the small pupil size, this ("tunnel effect") can affect people in buildings moving from a window area to an interior room without daylight. Permits reduction of lighting levels at night.
- *Demand Management Controls*. Decreases lighting levels and power in response to billing rates or utility requests to reduce power demand. Can be effectively used as a power curve flattening strategy in conjunction with real-time pricing.
- *Controls Networks for Lighting*. Equipment including controls and ballasts that communicate via network addresses to allow users to program control and energy-saving strategies.
- *Fluorescent dimming technology*
- *Incandescent dimming technology*.

- *HID Dimming Technology*.

APPLICATIONS Buildings of all types

BENEFITS Full control of lighting operation represents the single greatest systems opportunity to reduce lighting power demand and energy consumption in the Northwest. This benefit can only be realized through a systems approach with the use of integrated controls.

COST EFFECTIVENESS Highly dependent on type of control system, lighting requirements and building type. Some elements are modestly priced, while others require more expensive equipment. In general, can save a tremendous amount of energy. Cost effectiveness not as great in PNW due to low rates.

- Integrated controls can add $1 or more per square foot to the cost of a modern building.
- Tuning requires dimming ballasts, but can add as little as $10 to the cost of controls after that.
- Daylight dimming requires dimming ballasts and photoelectric devices that presently cost around $100 per system.

ACCEPTANCE PENETRATION Bits and pieces of technology are being specified for higher-end and specialized applications, e.g., computer intensive environments, energy demonstration projects, etc. In general however, minimal use and penetration. Many attempts at integrated lighting control systems have resulted in disaster due to poor specification, design, installation, commissioning, and/or maintenance. There are a number of abandoned systems out there. Many manufacturers of components, none of fully integrated systems.

BARRIERS Lack of awareness of full energy savings benefits offered by integrated controls; people aren't concerned with turning lights off or setting them back when not needed. Lack of financial incentive to better control lighting loads due to inexpensive power and little historical concern over peak demand. Need standardization of interconnection and consolidation of product offerings. Lack of easily addressable devices and zone controllers. Retrofit can be difficult where hardwiring is required; wireless technology and plug and play systems needed to revolutionize industry Virtually no comprehensive, well developed, cost-effective systems available. Limited to custom systems integration. Lack of universal, easy-to-use and effective integrated controls interfaces and devices. Lack of standardized interconnection protocol for controls communications.

SOURCES *Practical Control Strategies for Harvesting Daylight Savings*, Larry Kinney, E-Source Tech Update, July 2000
Rundquist, et al, *Lighting Controls: Patterns for Design*, EPRI 1997.

6.2.5 Halogen IR

TECHNOLOGY/ PRACTICE Halogen lamps employing burner envelopes coated with infrared reflecting film. Can increase filamentoutput from 14 or 15 lumens per watt (LPW) to around 22 LPW for lamps up to 100 W and 35 LPW for 900 W sources. Some examples are:

- *PAR30/HIR*. Medium aperture lamp 50 W for discreet track and recessed applications. Not especially suited for exteriors.
- *PAR38/HIR*. Large aperture lamp at 60, 80 and 100 W for track, recessed, and exterior applications.
- *MR16/HIR*. Small aperture low voltage lamp at 35, 37, and 50 W for discreet track and recessed lighting. Excellent for accent lighting, landscape lighting and sign lighting. Longest life HIR lamps.
- *Double-ended T-3/HIR Lamps*. Direct socket plug-in alternative 350 W and 900 W for flood lighting.
- *A/HIR*. Direct screw in replacement for standard A-lamps (not yet commercially available)

APPLICATIONS Many applications. Display lighting, general lighting, museum and landscape lighting in a wide range of residential, hospitality and commercial projects.

BENEFITS Simple screw-in and plug-in alternatives to standard halogen PAR 30, PAR38, MR16, and linear T3 double-ended halogen lamps; consumes up to 30% less power, offers extended lamp life.

COST EFFECTIVENESS Highly cost effective. (But where commodity incandescent "A" lamps are used, must bring down cost dramatically to compete).

ACCEPTANCE PENETRATION	Knowledgeable specifiers and national chains pushing halogen IR technology, but found in less than one third of all halogen sockets. Significant energy savings for little cost. With average accent lighting at one-to-two watts per square foot in higher end retail applications, halogen IR represents an enormous unrealized opportunity. Market monopoly by General Electric through 1990's limited number of adopters, competition now from Sylvania and Philips.
BARRIERS	Lack of supply can affect price and availability. Compared to generic halogen lamps, price premium can be 50-100%. Compared to premium halogen lamps, can be much less. Price different still too great in PNW region with such low utility rates. Manufacturers' specifications confuse less sophisticated buyers.
SOURCES	Manufacturers Literature (GE, Philips, Osram Sylvania) IES Lighting Handbook, 9th Edition Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.2.6 High Efficiency "Generic" Fluorescent Fixtures

TECHNOLOGY/ PRACTICE

Most common and universal commercial and industrial commodity lighting luminaire types. Optimized luminaire design based on the following: 1) high efficiency photometric performance and coefficient of utilization (based on general application): reflector design and material, lens or louver design and material, and source placement. 2) maximized lumen/watt source: high frequency electronic ballasts operation with advanced starting/operating circuitry, and high performance lamps phosphor blends and coatings (for maximum maintained lumens and life). 3) Careful thermal management (lamp orientation or fixture venting, heat sinking, or enclosure, and/or lamp gas fill chemistry; e.g., amalgam vs. non amalgam compact fluorescent lamps) to maintain optimum lamp mercury vapor pressure for high light output. Includes (but not limited to) the following products:

- 2×2 and 2×4 lensed troffers, optimized for premium T8 lamps with electronic ballasts and using high-reflectance specular reflectors to achieve high efficiency and coefficient of utilization (CU).
- 2×2 and 2×4 parabolic troffers, generally using premium T8 lamps with electronic ballasts, high reflectance diffuse reflectors, and carefully detailed louver designs to achieve high efficiency and CU

- Wraparounds, generally using premium T8 lamps with electronic ballasts and high reflectance specular reflectors to achieve high efficiency and CU.
- Indirect and semi indirect suspended luminaires using premium T8 lamps with electronic ballasts and optimum high reflectivity diffuse and/or specular reflectors to achieve high efficiency and CU
- Compact Fluorescent Downlights, generally using amalgam lamps with electronic ballast and optimal high reflectivity diffuse and/or specular reflectors to achieve high efficiency and CU.

APPLICATIONS

Most building types.

BENEFITS

- Improved source and fixture efficiency allows for lower wattage sources, fewer lamps, and/or deeper dimming or lower ballast factor power supplies.
- When used with premium (high color rendering, rare earth phosphor) 4-foot 32 watt T8 lamps, increased efficiency permits use of lower power ballast (low ballast factor), saving about 3 watts per lamp.
- Compact fluorescent downlighting: fixture efficiencies range from 35%-75%, with commercial grade specification products commonly performing at around 60% or more. A high performance downlight can produce the same illumination using a 26 W triple tube lamp as a conventional luminaire with a 32 W lamp, saving about 8 W per fixture.

COST EFFECTIVENESS

Generally good, as compared to conventional T8/electronically ballasted luminaires. Additional cost ranges from ten to fifty or more percent. Increased luminaire efficiency may permit use of lower ballast factor ballast, delamping or reducing the number of fixtures, resulting in fewer watts.

- Simply switching from normal ballast factor to low ballast factor electronic ballasts saves 10.5 kWh per year per 4-foot 32 watt T8 lamp, assuming 3500 hours per year operation.
- For compact fluorescent downlights, changing from a 32 watt lamp to 26 watts saves 28 kWh per year per lamp, can amortize increased cost quickly.

ACCEPTANCE

Knowledgeable designers and specifiers push the higher efficiency

PENETRATION options, but general awareness and concern is low, so the cheapest product gets installed. Wide variety of products available from numerous manufacturers.

- Reflectors: Given a bad name by questionable practices in the early/mid-90s, specular reflectors are useful in lensed fixtures. However, high reflectivity diffuse reflector materials are needed in open direct luminaires (e.g., parabolics) to prevent specular flashes deemed unacceptable in open luminaires.
- Compact fluorescents: Optimizing cutoff, aperture size, shielding and efficiency is a delicate engineering challenge in downlighting. Like troffers, there is an unfortunate tendency to genericize compact fluorescent downlights. While the product concept is widely accepted, careful selection is overlooked in favor of lighting "package" design.

BARRIERS Higher performance fixtures generally cost more, but not always, especially between the most basic commodity fixtures (using standard rather than enhanced performance reflectors). Most specifiers, distributors, and users are not concerned about fixture performance. Distributors stock the cheapest and/or most available products, regardless of performance.

The primary barrier is the tendency of the industry to genericize products, and to use "value engineering" as a means of reducing project cost, regardless of quality sacrifices, to pay for overruns in other portions of the project. At low NW utility rates, developers place greater value in building finishes and other features than in lighting and energy.

SOURCES Rising Sun Proprietary Studies, Interview with Michael Siminovitch, Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.2.7 T5 Lighting Equipment

TECHNOLOGY *Standard T5 lamps and electronic ballasts:* used in various recessed, surface mounted and suspended luminaires. The T5 system is prevalent in Europe and the lamps are metric sizes. Straight lamps are metric lengths: slightly less than two feet (1,350 lumens (L), 14 W), slightly less than three feet (2,100 L, 21 W), less than four feet (2,900 L, 28 W) and just under five feet (3,650L, 35 W). Circline lamps are 12" diameter 40 W and 8.8" diameter 22 W.

High Output T5 (“HOT5”) lamps and electronic ballasts: also used in various recessed, surface mounted and suspended luminaires. The T5 system is prevalent in Europe and the lamps are metric sizes. Straight lamps are metric lengths: slightly less than two feet (2,000 L, 24 W,) less than three feet (3,500 L, 39 W), less than four feet (5,000 L, 54 W) and less than five feet (7,000 L, 80 W). Circline lamps are 12" diameter 54 W and 8.8" diameter 40 W.

Evolving important luminaire applications include:

- Suspended linear indirect and direct/indirect luminaires
- Cove lights and wallwashers
- Valences, strips, undercabinet lights and other utility luminaires
- Specialty compact luminaires

APPLICATIONS

Wide range of commercial, industrial institutional and residential projects.

BENEFITS

Standard T5 lamps and ballasts: High efficacy (95+LPW), high lumen maintenance, high color rendering (80+) rare earth phosphor, thin cross-section, dimmable lamps, rated 20,000 hour lamp life. Permits use of smaller cross section luminaires than T8 or T12, resulting in reduced luminaire material cost, installation labor, etc. Compared to T8 , the T5 lamp produces 7.5% more light for the same power. Thinner lamp profile makes additional luminaire optical efficiency gains possible over T8 lamps where T5 luminaires are optimally designed around source: about 5% greater fixture efficiency and up to 20% wider luminaire mounting spacing possible for office linear suspended indirect luminaires; around 10% greater fixture efficiency possible for indirect cove lighting and direct wall washing luminaires.

High Output T5 (“HOT-5”) lamps and ballasts: High efficacy (85+LPW), high lumen maintenance, high color rendering (80+) rare earth phosphor, thin cross-section, dimmable lamps, rated 16,000 hour lamp life. Permits use of smaller cross section luminaires than T8 or T12, resulting in reduced luminaire material cost, installation labor, etc. The HO system produces 95% of the output of two premium T8 lamps operated on a standard electronic ballast for the same power, and factoring in its thinner profile optical advantages has an overall luminaire efficacy gain.

COST

At present good for specialized applications. The long term prospects are high. As compared to current T8 lamp/ballast technology, two to

EFFECTIVENESS three times the cost.

ACCEPTANCE PENETRATION Knowledgeable designers and specifiers are promoting technology for higher-end, specialized applications. Lamps only manufactured by Philips and Osram, ballasts manufactured by multiple sources. All manufacturers of linear luminaires have embraced the technology.

BARRIERS T8 lamps and compact fluorescents are finally mainstream. General marketplace is not yet willing to embrace another new (similar) technology. Lamps are not readily available, and cost three times more than T8 lamps, but are equivalent to compact fluorescent prices. Most general practitioners and users not familiar with the technology. T8s cannot be retrofitted to T5 lamps because new fixtures are needed. Requires dedicated ballasts with lamp end-of-life cut-out circuitry.

SOURCES Luminaire Apparent, Peter Franck, LD+A, May 2000. pp. 92-94

6.2.8 Modern Metal Halide Lamp/Ballast Systems

TECHNOLOGY Important developments in metal halide technology that minimize or eliminate problems with traditional "probe start" lamps including inconsistent color temperature, fair color rendering, poor color stability, high lumen depreciation, significant ballast losses and large lamp size. Following are the primary developments:

- (Re)discovery of reactor ballasts
- Improved starting and operating circuitry ("pulse start" lamps and ballasts).
- Improved arc tube (ceramic discharge tubes): 39W to 100W
- Reflectorized metal halide PAR sources: 39W-100W, PAR20, PAR30, PAR38
- Electronic ballasts

APPLICATIONS High bay/low bay fixtures, streetlights, flood lights, canopy lights, recessed downlights, track lighting, etc.

BENEFITS

Improved lamp/ballast system efficacy and lumen maintenance allows for lower wattage sources to provide equivalent long-term light output. Better color rendering sources, smaller and lighting components, and reflectorized lamps increase applications.

COST EFFECTIVENESS

Compared to traditional metal halides, slight to moderate increase of price. Generally, highly cost effective.

ACCEPTANCE PENETRATION

Like T8 fluorescents, "modern metal halide" systems should be standard practice today, but they are still the exception rather than the standard. Knowledgeable specifiers and major users are sold on them, where the economics make sense. Most engineers, contractors and salespeople overlook the new metal halides. All major lamp and ballast manufacturers offer modern metal halide components/systems options.

BARRIERS

Some manufacturers aggressively promoting technology while others waiting to get pulled along by market demand. Premium cost.

SOURCES

Manufacturers Literature (GE, Philips, Osram Sylvania, RUDD, Venture), Rising Sun Proprietary Studies
Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.2.9 Modern Industrial Fluorescent Lighting

TECHNOLOGY

1) Fluorescent alternatives to conventional HID industrial-style lighting. Modern fluorescent lighting has superior color rendering, color stability, lumen maintenance, starting/restarting time, lamp life, flicker free operation, and dimming capability. 2) Improved application of modern fluorescent sources and fixture types in place of standard industrial fluorescent systems:

- 8' Strips, Industrials, and recessed channel fixtures using 4-ft or 8-ft Lamps
- Industrial-HID style luminaires (high bay, low bay, and canopy) with multiple compact fluorescent T4 triple or T5 twin-tube lamps

APPLICATIONS

Industrial, grocery, gymnasiums, showrooms, convention facilities, big box retail, and low to medium bay retail.

BENEFITS

Improved lamp, ballast, and fixture options allow for up to 40% power reduction, increased lamp life, improved color rendering, consolidation of lamp types, and increased lamp lumen maintenance. Instant on and instant re-strike capabilities and dimming ballast options offer ability to readily control in response to daylighting, tuning, scheduling, and occupancy.

All fixture types can be retrofitted or ordered new. The modern 8-ft system can employ T12 or T8 premium lamps (80+ color rendering, rare earth phosphor) with electronic ballasts, but the commodity pricing, ease of handling, and variety of electronic ballast offerings for the 4-ft T8 premium lamps makes them a more desirable option for use (tandem mounted, end-to-end) in most 8-ft fixtures. When used with electronic ballasts and premium phosphor coated lamps, fluorescent systems can generate 90+ LPW with lumen maintenance of 0.92 or better and lamp life exceeding 15000 hours. This compares very favorably to metal halide systems (see Section 6.9) which, due to lumen maintenance of only 0.65 generate fewer maintained lumens per watt.

High bay/low bay multiple compact fluorescent lamp fixtures: easier to control that HID counterparts (instant on, instant restrike, easy to step dim with multiple lamps), better lumen maintenance, equivalent or better maintained efficiency, good color rendering.

COST EFFECTIVENESS

Overall system cost is generally higher than metal halide because more luminaires required. Little or no additional cost compared to T8 electronically ballasted fluorescent fixtures. Moderately to highly cost effective depending on base case and/or ability to fully control fluorescent source for energy savings.

ACCEPTANCE PENETRATION

Knowledgeable designers and specifiers are recommending the most appropriate systems, but over the counter contractor and retail sales go to the lowest cost (and lowest efficiency) products, which are commonly poorly matched to the photometric requirements of the application. Modern industrial fluorescent systems are manufactured by numerous sources.

BARRIERS Lack of understanding about all the options. Many specifiers, distributors, contractors and users aren't very concerned about the performance of commodity industrial fixtures. Distributors generally stock the least expensive and/or easiest product to procure, regardless of performance. Strip fixtures are very commonly installed where the photometric performance of an industrial luminaire (reflectorized strip) would be far more effective.

SOURCES *Competing Technologies Vie for Eight-Foot Fluorescent Fixture Market: Evaluating the Alternatives*, R Sardinsky and B. Heckendorn, E-Source Tech Update, March 1999

6.2.10 Compact Fluorescent Luminaires

TECHNOLOGY Expanded use of compact fluorescent luminaires in typically incandescent applications. Some of the opportunities that are underutilized include:

- Low bay and high bay compact fluorescent luminaires (T5 twin tube and T4 triple)
- Portable table and floor lamps and torchieres with hardwire compact fluorescent
- Compact fluorescents track-mounted wall washer fixtures
- Decorative hardwire compact fluorescent fixtures (sconces, pendants, surface mounts, etc)

APPLICATIONS General decorative lighting and task lighting in hotels, motels, institutional, commercial and similar locations.

BENEFITS Very significant energy savings (up to 75%) and maintenance savings (extended lamp life) alternative for most general incandescent applications.

High bay/low bay: easier to control than HID counterparts (instant on, instant restrike, easy to step dim with multiple lamps), better lumen maintenance, equivalent or better maintained efficiency, high color rendering.

COST EFFECTIVENESS Relatively modest to poor due to low NW utility rates.

ACCEPTANCE PENETRATION In widespread use in recessed downlights, extraordinary energy savings opportunities remain in other applications.

BARRIERS Very limited interchangeability between lamps provides no flexibility in relamping for different lighting levels; dimming ballasts add significant cost and color shift during dimming. Not acceptable in many applications. Too many lamp types and fixture lamping configurations. High first cost, lack of demand and acceptance.

SOURCES *New High-Intensity Fluorescent Lights Outshine Their HID Competitors*, J. Rogers and I. Krepchin, E-Source Tech Update, January 2000

Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.3 SELECTED REGION-WIDE POTENTIAL ESTIMATES

In this section we provide rough estimates of the potential savings which could be achieved by increasing the penetration of the C&I lighting technologies and practices discussed in Section 6.2. Note that all of the potential estimates presented in this report are only approximate, a full potential analysis was not within the scope of this study.[15] Within the scope of this study, our objective for presenting potential estimates is modest: the purpose is simply to provide the Alliance with a general sense of the available potential so that it can take the relative potential of the lighting market into account when comparing the C&I lighting initiative area with other opportunity areas it may be considering. With that backdrop, we present a few important caveats of which the reader should be aware: 1)the potential estimates presented are tied to base usage amounts that were developed by the Northwest Power Planning Council through its end use forecasting model, which was last calibrated around 1995, thus, the forecast of growth rates by business type may be significantly biased;[16] 2) estimates of potential are provided only for the commercial sector[17]; 3) because no comprehensive data source was available on the saturation of high-efficiency lighting technologies in the existing population of buildings for the entire PNW, we used data from Pacific Gas & Electric Company's latest commercial end user survey (which includes 1,000 on-site surveys conducted in 1996 and 1997) as the best available proxy for electronic ballast and CFL saturations by building type; and 4) we used data previously compiled and analyzed by XENERGY for the energy-efficiency component of Portland General Electric's (PGE) least-cost planning process from the mid-1990s;[18] including avoided costs.[19]

[15] XENERGY has conducted dozens of energy-efficiency potential studies. These studies require extensive analysis of measure costs, savings, baseline population forecasts, saturations of existing equipment, and the like. As a frame of reference, consider that the budget resources applied to most energy-efficiency potential studies equals the entire budget of the current study. Estimating the total potential of lighting savings in the current study, however, represents only a small portion of the total scope (less than 5 percent).

[16] Key data utilized from the NWPPC's model included: floorspace and end-use energy consumption for lighting in kWh per square foot by building by year for both new and existing construction.

[17] This is because the commercial baseline data was readily available from the NWPPC forecast model, whereas no comparable data is available on industrial lighting loads over the next ten years. Our team is fully capable of making such estimates, however, the amount of effort required would exceed the available scope for this task. At a qualitative level, current sources indicate that the industrial lighting load may be roughly 15 percent of the total C&I lighting load.

[18] A key source compiled for PGE that we also used in this study was analysis of PNONRES on-site data, which was collected circa 1991. This data was used to characterize the share of base case fixture types by building, e.g., 4-foot versus 8-foot fluorescent.

[19] We checked these avoided costs against avoided costs currently being used by the Alliance in its cost-effectiveness tests and found the two to be relatively close. However, we note that both sets of avoided costs are significantly below current market prices in the western region of the United States. In particular, neither set reflects the premium prices being paid for peak power during summer. Analysis of avoided costs is also being the scope of this study, we believe the values used are conservative and, hence, the remaining economic potential is likely higher than the results presented in this report.

6.3.1 Methods

Two methods were used to developed the potential estimated presented herein. To estimate the remaining potential in existing construction, we used a bottom up methodology (described below). For the new construction estimates, a top down method was used. The reason for the difference in approach is described below.

Existing Construction - Bottom Up Supply Curves

In the case of existing construction, we were able to use a bottom up methodology because of several factors: 1) we were able to populate the required inputs for our modeling software, DSM ASSYST, with modest effort by adapted work previously conducted for PGE; 2) most of the remaining potential in the existing construction market is still associated with simple like-for-like technology substitutions that lend themselves to the supply-curve methodology used in our model, for example, swapping magnetic for electronic ballasts, incandescents for CFLs, and retrofitting lighting controls. In addition, cost and savings data for these technology substitutions are readily available. Given these conditions, we were able to produce bottom-up supply curves of the remaining technical and economic potential quickly and with modest use of project resources.

DSM ASSYST uses a series of macro-linked spreadsheets to estimate energy-efficiency potential and cost effectiveness and to rank energy-efficiency technologies by market segment using user-specified criteria. Technology-specific engineering data are integrated with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system. The result is that many measures can be evaluated simultaneously using a variety of cost-effectiveness criteria.

Technical Potential-Basic Equation

The core equation used in DSM ASSYST for calculating each technology's technical potential by market segment is as follows:

Technical Potential of = Energy-Efficiency Measures	Equipment EUI	x Square Feet	x Applicability Factor	x Not Complete Factor	x Feasibility Factor	x Savings Factor

where:

Equipment EUI is the energy used per square foot by a particular base-case technology in a given market segment. This is the energy-using equipment that an energy-efficiency measure replaces or affects, for example, compact fluorescent bulbs replacing incandescent lighting. **Applicability Factor** is the fraction of the sector floor space that is appropriate for conversion to the energy-efficiency technology in a given market segment, for example, the percent of floor space in the office sector lit by incandescent bulbs. **Not Complete Factor** is the fraction of end-use applicable floor space that has not yet been converted to the particular energy-efficiency measure; that is, (100 - energy-efficiency measure saturation)/100. **Feasibility Factor** is the fraction of the applicable floor space that is technically feasible for conversion to the energy-efficiency technology from an *engineering* perspective. **Savings Fraction** is the change in energy consumption resulting from application of the energy-efficiency measure.

Estimation of Cumulative Technical and Economic Potential

After all of the *individual* energy-efficiency options' impacts have been estimated, the *cumulative* technical potential across measures is determined by developing energy and demand efficiency supply curves. The purpose of the technical potential supply curves is to adjust for the effects of overlapping options that are targeted at the same base-case technologies and building types. This is done by applying the technologies sequentially and logically to the annual usage estimates for each base-case technology within a given market segment. The supply curves make these adjustments by taking into account the increasing sector end-use efficiency that occurs as the most cost-effective energy-efficiency resources are implemented. Thus, in the supply curves, the sector usage of the base-case end use is reduced with each unit of energy-efficiency that is acquired.

The costs and savings of each sequentially applied energy-efficient measure are then calculated *incrementally* to each of the previous measures in the supply curve. In this way, marginal costs and energy and demand savings are calculated as each technology is applied to the same end use and market segment. The *economic* potential can then be calculated by summing the energy savings for all of the technologies for which the marginal benefit-cost ratio is greater than 1.0. The supply curve methodology thus yields estimates of the technical and economic potential of efficiency improvements along with the corresponding total, average, and marginal costs of conserved energy and avoided capacity.

New Construction - Top Down Design Improvement Scenarios

In the new construction market the situation is significantly different. First, as demonstrated by the Alliance's recent on-site-based study of new construction building practices, and discussed in Section 5, most of the new construction market has already converted to the high-efficiency technologies that can be easily modeled through like-for-like substitutions. The majority of the remaining potential in new construction is associated with improvements in lighting design and the integrated use of daylighting and lighting controls. These types of improvements do not lend themselves well to a bottom up analysis, generally, and, in particular, such an analysis could not be done within the scope of the current study. A detailed bottom up analysis of the potential for lighting savings in new construction would require characterization of dozens of designs by base case space types and development of efficient alternative designs for these cases. In particular, estimating the incremental costs, if any, associated with the higher-efficiency designs would take an extensive effort. Few, if any, such comprehensive analyses have been conducted nationally to date. In fact, one of our recommendations for initiatives the Alliance should consider, see Section 7, is to develop high-efficiency design templates that would match and replace default templates and rules-of-thumb used by many lighting designers.

As a result of these constraints, we chose a simple top-down approach for new construction. In this approach we simply estimated the potential reduction in base case lighting consumption based on two levels of improvement in current practice. (Our general guide to current practice was based on the opinions of the lighting experts on our team , the lighting power densities presented in the Alliance's new construction on-site study, and the current regional energy codes as well as the latest ASHRAE 90.1.) The two levels are defined as follows:

- *Moderate Improvements in Current Design Practice* - This scenario represents a 10 percent reduction in lighting power densities and associated energy usage below current practice. This decrease would be achieved through modest design changes that focus on better optimization of fixture layout and product choices, but would not require aggressive use of controls. This scenario represents most of the opportunity described under Energy Effective Lighting Design under Section 6.2.1 and technologies covered under Sections 6.2.5 to 6.2.10.
- *Aggressive Improvements in Current Design Practice* - This scenario incorporates all of the savings associated with the Moderate Improvement scenario and adds savings associated with advanced lighting controls and daylighting design (see Sections 6.2.2 through 6.2.4). This represents a 20 percent reduction in energy usage below current practice. Note that summer peak demand savings would be higher under this scenario due to the coincidence of available daylight with this period.

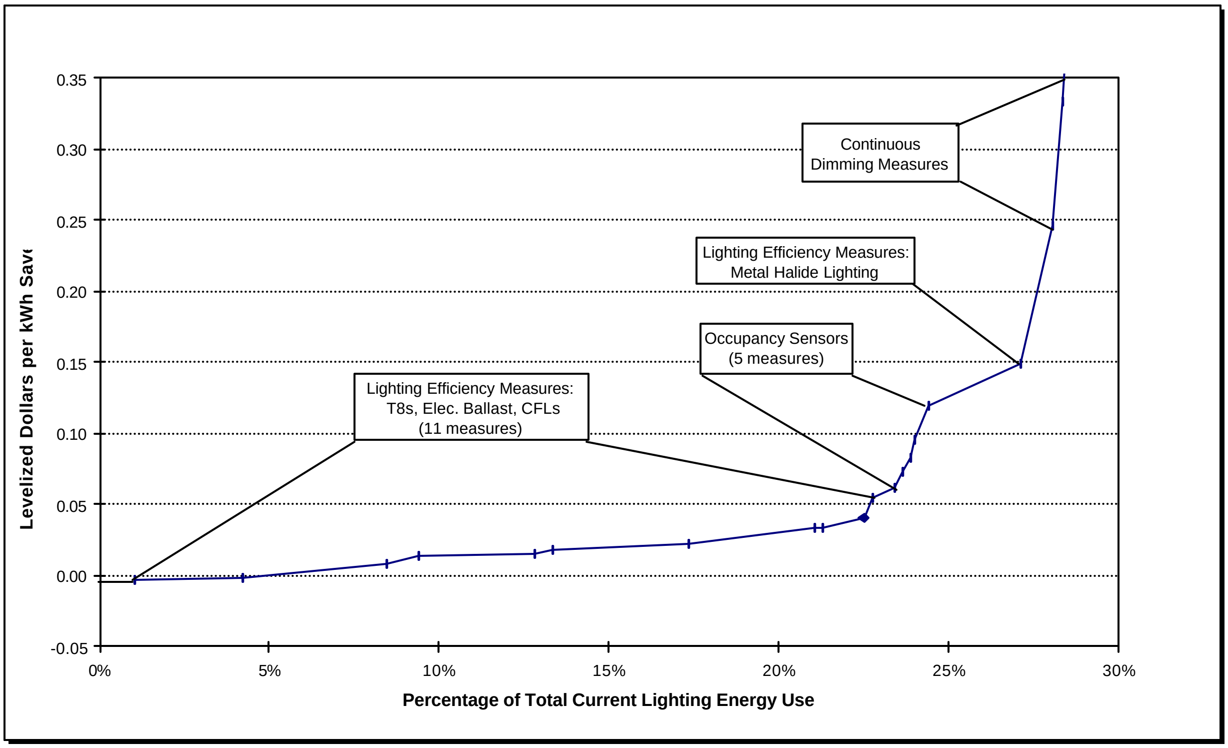
Under our simplified approach for new construction, we have simply taken the 10 percent and 20 percent savings potentials described above and applied these to the total base case lighting usage associated with growth in the new construction market over the next 10 years.

6.3.2 Results

Summaries of the bottom up-based remaining potential within the existing construction market are provided in Figures 6-1 through 6-3. Note that the incremental not full costs of the efficiency measures were used in calculating the levelized costs of conserved energy. Key results this analysis are discussed below.

There is roughly 30 percent of technical and at least 17 percent of economic potential remaining in the existing construction lighting market. Importantly, the economic potential could be significantly higher depending on avoided costs. As shown in Figure 6-1, the economic potential increases to about 23 percent if the levelized cost threshold moves up from about 2.5 cents per kWh saved to 5 cents per kWh saved. Also note that most of the remaining economic potential is associated with T8 lamps/electronic ballasts (T8/EBs) and compact fluorescent lamps (CFLs). Occupancy sensors are somewhat above the 5 cent per kWh saved leveled cost when considered on the margin (that is, after implementation of T8/EBs and CFLs. In addition, since the supply curve analysis is based on the average hours of use for lighting within each building type, it does not fully capture the economics of occupancy sensors which are most cost effective when applied to the portion of space with operation hours that exceed occupancy and other needs. On the margin, perimeter dimming is very expensive from an energy-only point of view. This is consistent with analyses conducted by XENERGY and others in previous potential studies. Societal economics for perimeter dimming are very sensitive to the value associated with peak (day-time) demand reduction, while customer economics are equally sensitive to whether the value of peak demand reductions is translated into end user price signals. Without high on-peak price signals, perimeter dimming is generally not cost effective for customers on a retrofit basis.

Figure 6-1
Commercial Sector Lighting Supply-Curve* - Existing Stock, Base Year = 2000



As shown in Figure 6-2, on a percentage basis Offices and Groceries have less remaining potential than most other segments, this is because we have assumed they have already implemented a higher share of efficient technologies than the other segments (again, using the PG&E data discussed above as a default proxy for saturation by segment in the PNW). Nonetheless, on an absolute basis, Offices still have the largest remaining potential, as shown in Figure 6-3, this is because they dominate overall commercial sector lighting with 30 percent of the base usage (see Section 4 for summary of base regional lighting use).

Figure 6-2
Percent Lighting Potential by Building Type, Existing Stock, Base Year = 2000

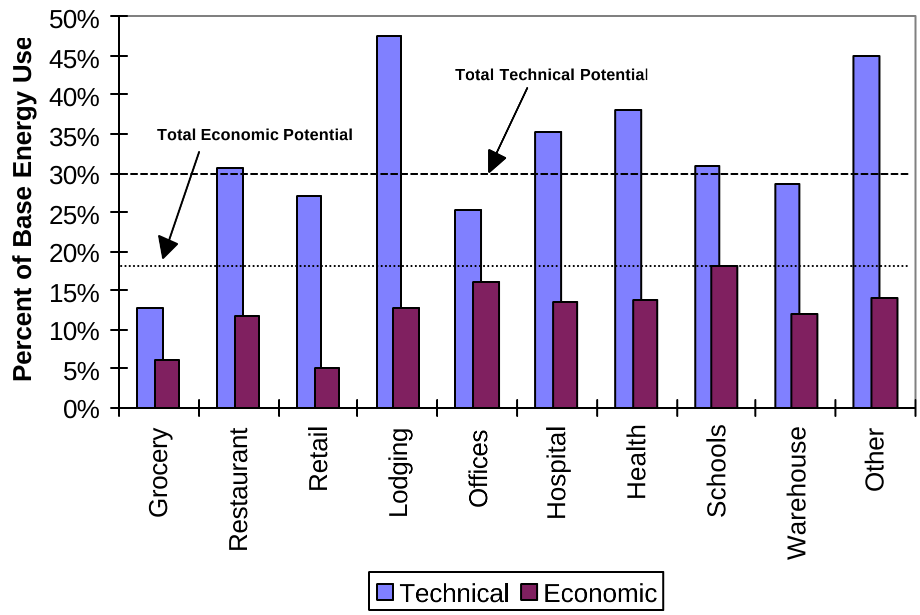
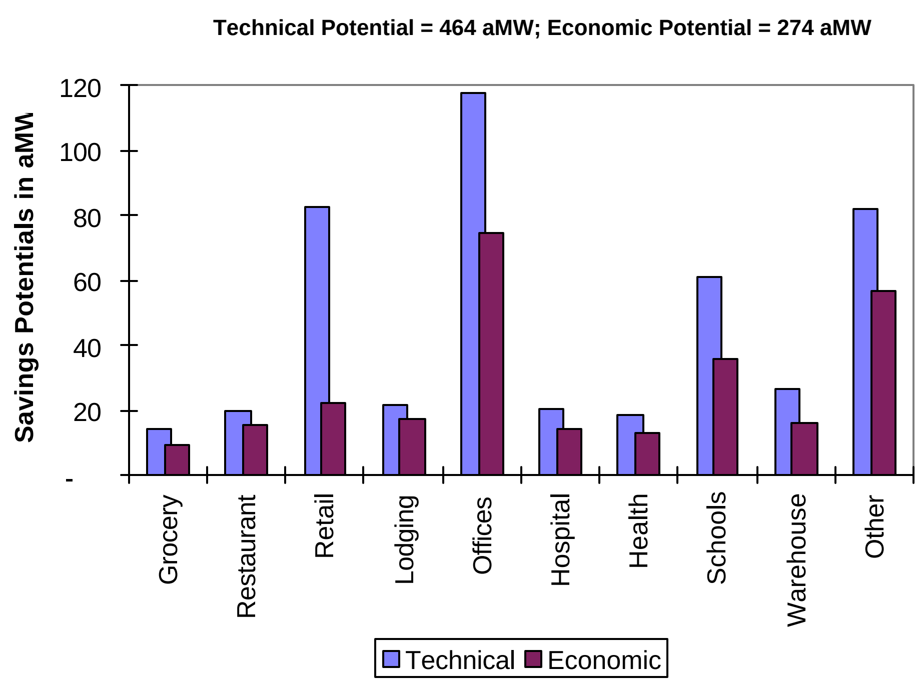
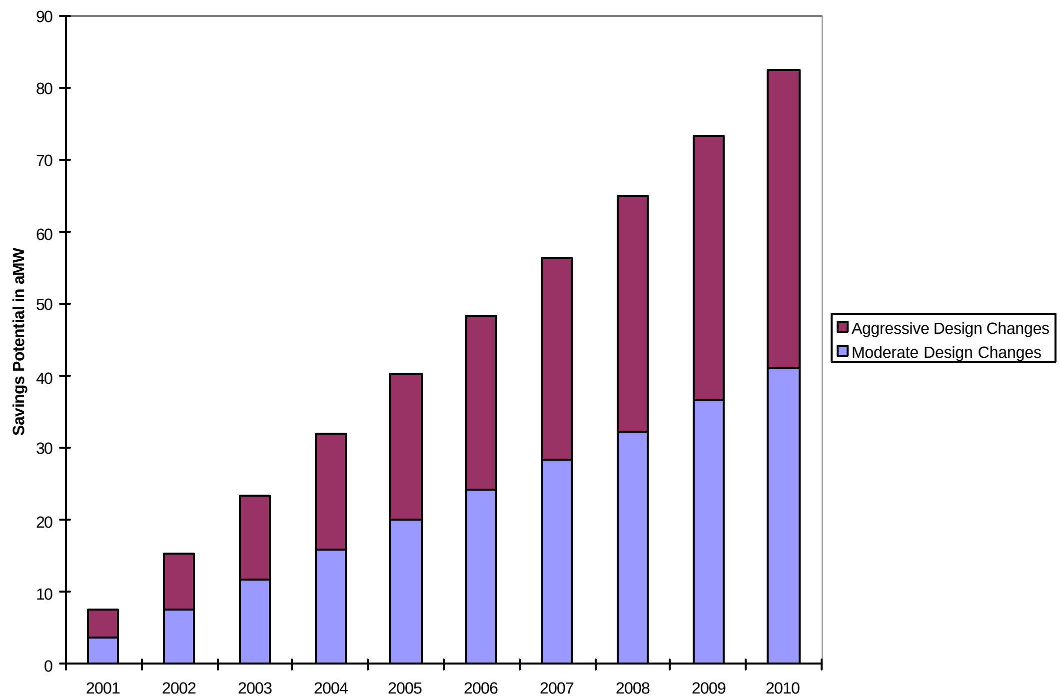


Figure 6-3
Lighting Potential by Building Type, Existing Stock, Base Year = 2000



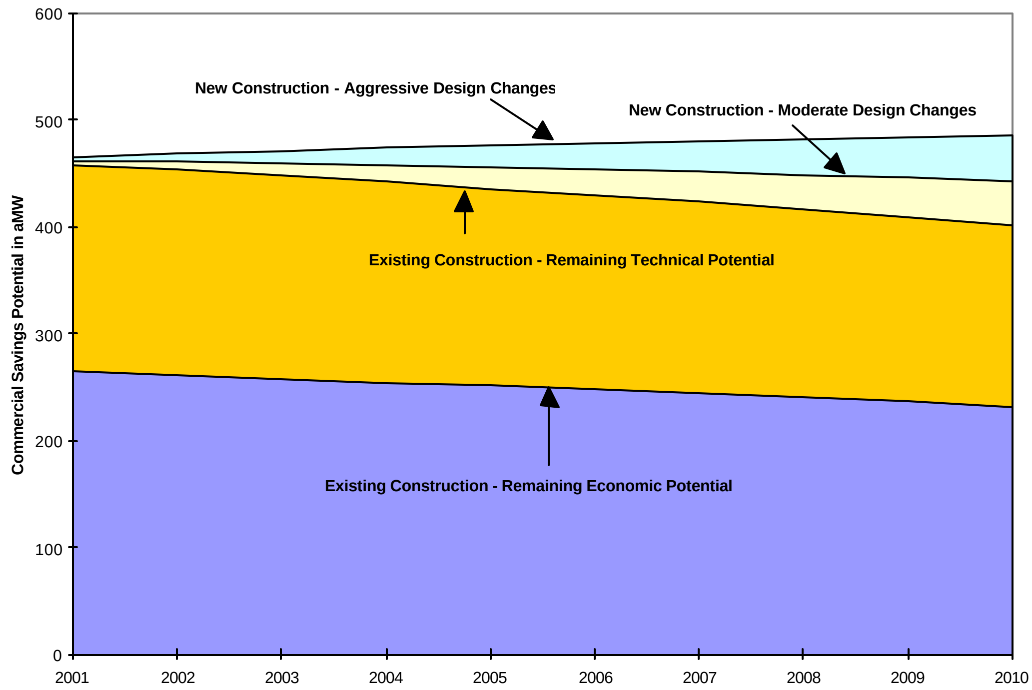
In Figure 6-4, we show a summary of the potential savings in aMW in the new construction commercial market for the period 2001 to 2010 under the Moderate and Aggressive Design Change scenarios described previously. A shown in the figure, a 10 percent improvement in lighting power density across all commercial building types would result in approximately 41 aMW of savings by the year 2010. A 20 percent reduction in lighting usage, which would require extensive use of controls and daylighting, would produce 82 aMW of savings by 2010.

Figure 6-4
New Construction Potential Under Moderate (10% Savings) and Aggressive (20% Savings) Design Changes



The combined pool of available savings from remaining potential in the existing construction market and the two new construction design scenarios is shown in Figure 6-5. Over the next 10 years, the existing construction market still holds the majority of the remaining savings potential in the region; however, influencing the new construction market is also critical because of the importance of avoiding lost opportunities and the opportunity to build best practice design into the building design process when it is least expensive and most advantageous to maximizing lighting savings.

Figure 6-5
Combined Potentials - 2001 to 2010



Although estimates of the total potential available are important for planning purposes, it is important not to mistake technical and economic potential for what is achievable in the market through program initiatives. Estimation of market and program potential are beyond the scope of the present study, however, we have provided a hypothetical example of what an achievable potential target might produce. In Figure 6-6, we provide a hypothetical case in which a 5 percent improvement in lighting use is achieved in new construction (i.e., 50 percent of the Moderate design change scenario presented previously) and one-third of the remaining economic potential in the existing market is captured (equivalent to roughly 6 percent of current base use). The result would be savings of 21 aMW in the new construction market and 82 aMW in the existing market, for a total of 103 aMW by the year 2010. Lastly, Figure 6-7 summarizes all of the potential estimates for the year 2010.

Figure 6-6
Hypothetical Example of Achievable Potential Target - 2001 to 2010

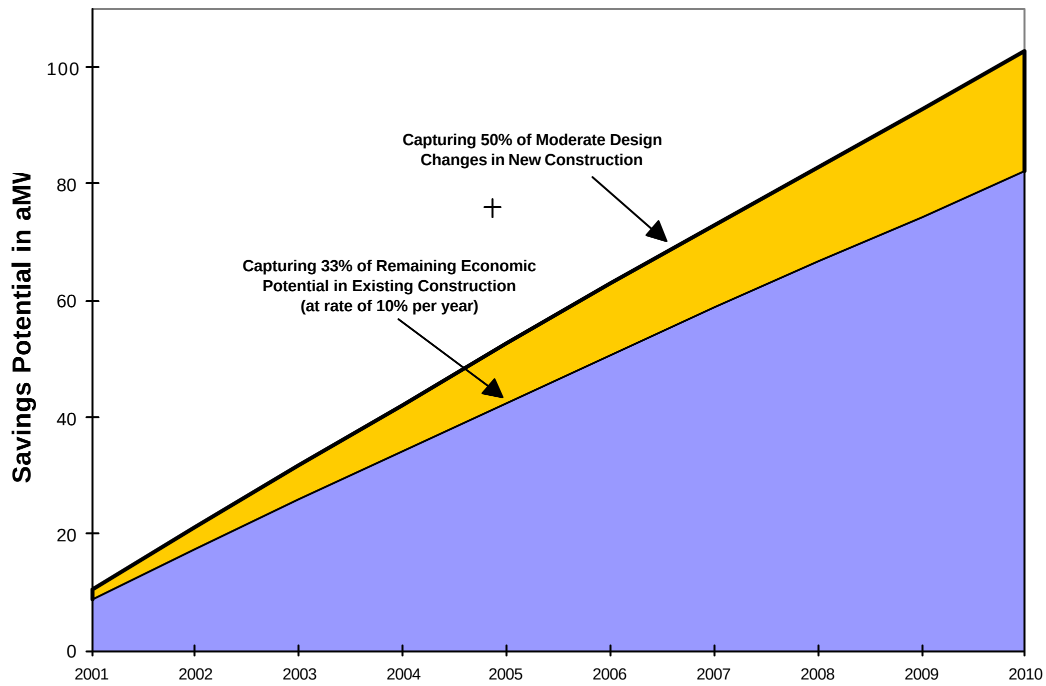
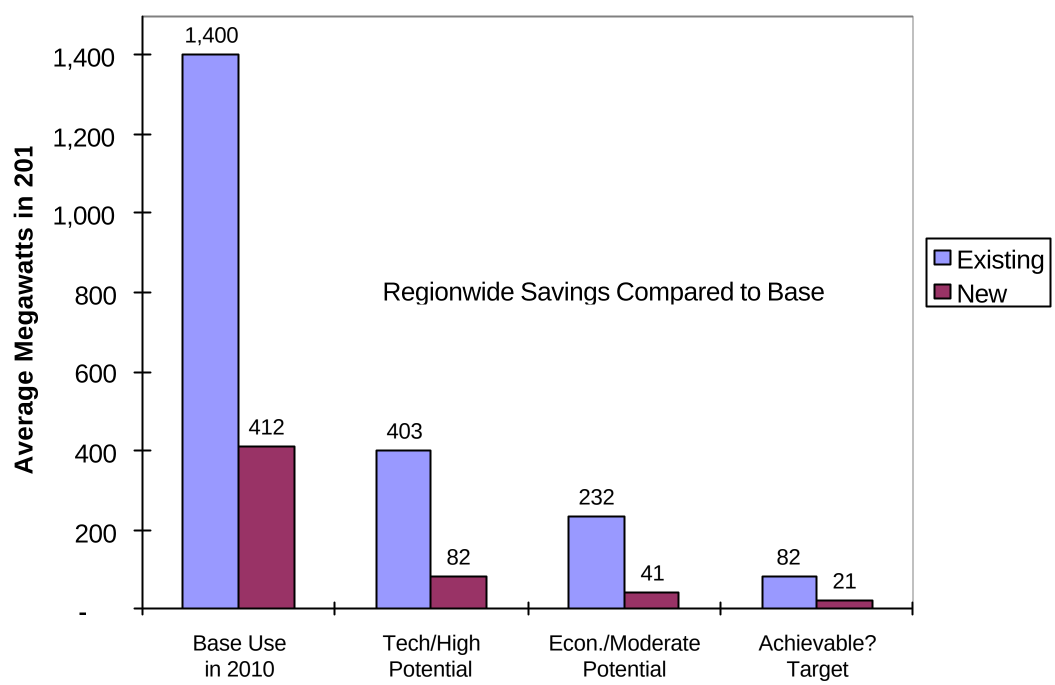


Figure 6-7
Overall Summary of Lighting Potential and Hypothetical Target - 2010



6.4 SECOND TIER TECHNOLOGIES AND PRACTICES

Listed below are the measures which were not considered as being first-tier material. Reasons for exclusion from the "top ten" list include cost barriers, infancy of the technology, lack of proven energy savings, lack of proven performance, and/or lack of knowledge.

6.4.1 New Light Emitting Diode Systems (LED's)

LED's are being integrated into new point source arrays and electroluminescent panels to expand their applications. With the advent of white-light LED's, lighting uses beyond exit signs and traffic lights are being pursued. Most prominent uses will probably be in downlights, tasklights, neon substitutes, and luminous panels. Practical general lighting applications are five or more years in the future, if at all. Numerous major manufacturers working on sources and systems for LEDs.

Benefits

- High (red and amber) to moderate (green and blue) source efficacy
- Wide variety of tightly controlled beam spreads possible (increasing lamp and fixture efficiency in directional applications)
- Long life (20 years and up is typical)
- Solid state low voltage DC source easily and inexpensively controllable (dimming)
- Color shift can be precisely adjusted
- Radically more compact luminaires possible
- White light can be created using trichromatic arrays of Red, Blue, and Green LEDs

Barriers

- Efficiencies need to be raised and cost reduced.
- Lumen depreciation too great for white source LEDs

Source

- The End of Light As We Know It, Sidney Perkowitz, *New Scientist Magazine*, Vol. 165 issue 2220, 2000:8, p.30, Interview with Michael Siminovitch, LBNL

6.4.2 Scotopically Rich Sources

Higher color temperature (>5000K) fluorescent and metal halide sources with a spectral distribution biased toward the blue end of the visible spectrum. Standard illuminance (footcandle) measurements only read photopic sensitivity (cones in the eye are photopically biased for daytime vision) not scotopic sensitivity (rods in the eye are scotopically biased for night time vision). Scotopic effects can impact depth of field at indoor lighting levels, and blue rich sources produce dramatic increases in visibility as light levels get lower.

Benefits

- Potentially, can increase productivity of employees
- Allows for better focus of the eye at lower lighting levels

Barriers

- Lack of knowledge and understanding by the general public
- Thesis hasn't been proven whether or not blue enhanced light can be used as a means to save energy through reduce lighting levels
- Unsure of the degree to which color spectra affects humans' circadian rhythms (daily physiological awake and sleep cycles) and whether blue rich light would positively or negatively impact this

Sources

- LBNL
- Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.4.3 Fiber Optic Lighting

Utilizes metal halide lamp (or other light source) which delivers light to multiple areas/spaces through the use of fiber optics. Possible waning technology. Appears relegated to museum lighting and special effects because of the very high costs associated with reasonably efficient systems. Numerous manufacturers offering systems; many players working relatively small marketplace.

Benefits

- Single source feeds entire room or application
- Can bring daylight to interior spaces

Barriers

- Fundamentally inefficient system: combination of losses in illuminator/optic coupling, fiberoptic, and output devices are excessive
- High first cost for illuminators and optics
- Skilled design and installation required
- Long term performance not proven
- Best metal halide downlighting system performance only equals that of standard incandescent one

Source

- Rising Sun and Benya Lighting Design Proprietary Report for Con Edison Solutions

6.4.4 Induction Lighting

Induction lamps are fluorescent lamps in which a radio frequency field (rather than an electric arc) excites the gas, producing light. Because of the lack of an electrode, the lamps last longer than standard fluorscent lamps. The product is offered from 20W screw-ins up to 150W hardwire sources. The best current use is for street and park lighting where relamping cost justifies the first cost. GE, Osram, and Philips each offer a small family of products. The three primary product types are:

1. A 23W screw-in CFL-style lamp by GE
2. Hardwired 55, 85 and 165W bulbous lamps from Philips
3. Hardwired 100 and 150W rectangular ring lamps from Osram Sylvania

Benefits

- Long life source: up to 20,000 hours for screw ins and 100,000 hours for hardwire products
- High color rendering
- Instant on and instant restrike
- Can be frequently cycled on-off without premature lamp failure.

Barriers

- Moderate efficacies 50-70 lumens per watt limit its current applications
- High first cost
- Lumen depreciation

Sources

- Manufacturers Literature (Philips, GE, Osram Sylvania)
- IES Handbook 9th Edition
- Advanced Lighting Guidelines 2000, second review draft, various authors, www.newbuildings.com

6.4.5 Sulfur Lighting

The sulfur lamp consists of a small glass ball in which sulfur is excited by intense microwave energy. This a cool greenish-white light to be emitted, with a theoretical efficiency much higher than metal halide. The small lamp size provides the potential for extremely efficient optical systems. Lamps come in a range of sizes up to 1000W. The sulfur lamp is a promising technology, best suited for centralized light distribution or higher intensity projection applications.

Benefits

- Extremely long life source
- Very compact, high lumen source
- High efficiency potential with marginal color acceptability
- Moderate efficacy potential with good color acceptability

Barriers

- Current microwave generator lasts only about 10,000 hours
- Requires constant lamp rotation for cooling and even heat distribution
- Extremely high cost
- Needs color correction to be useful in habitable spaces.
- Costly methods required for light distribution from this very-bright source

6.4.6 Switchable Glazings

Variable transmission permits "dimming" of natural light. Best suited for daylighting applications, where entire glazings can be controlled for incoming light.

Benefits

- Greater control of natural light in daylighting situations

Barriers

- Extremely high cost and moderate energy efficiency gains

6.4.7 Hot Cathode T2 (Subminiature) Fluorescent Lamps

Specialty display lighting, task lighting, and valence lighting.

Benefits

- High color rendering
- Very compact, linear source
- Optimum lumen package for common close proximity task (under shelf) and display (cases, racks, shelving) lighting installations
- 10,000 hour lamp life

Barriers

- High cost
- Not suitable for lighting large areas
- Sole source

Sources

- Manufacturers Literature (Osram Sylvania)
- IES Handbook 9th Edition

7 MARKET INITIATIVES TO CONSIDER

In this section we present a discussion of new C&I lighting market initiatives for the Alliance to consider. First, however, we provide an overview discussion that outlines our general thinking about the ways in which the current market might be approached. We also provide a summary of C&I lighting initiatives being implemented elsewhere in the United States and a summary of related initiatives currently or recently supported by the Alliance.

7.1 CONTEXT, BARRIERS, AND PHILOSOPHICAL CONSIDERATIONS

This section provides a brief discussion of how we think this market should be approached at the most general level. We believe the evidence shows that there is substantial opportunity for achieving cost-effective and sustainable improvements in lighting usage in the PNW. However, it also appears that influencing this market will be challenging.

7.1.1 Context - Past Success As Challenge to Future Success

Because of the energy efficiency community's successes during the past decade in transforming much of the C&I lighting market from T12 lamps and magnetic ballasts to T8 lamps and electronic ballasts (EB), and from incandescent lamps to compact fluorescent lamps (CFLs), transforming the current C&I market will be more difficult.[20] What then are the challenges to the new C&I lighting initiatives inherited from these past successes? Consider the following:

- By reducing lighting power consumption significantly (20 to 50% per fixture for T8/EB replacements and 50 to 75% for CFLs), ***there is less energy consumption and associated cost*** remaining ***from which to obtain and cost justify additional efficiency improvements*** (for example, occupancy sensor savings are reduced proportionally by improvements in fixture efficiency).
- Having achieved significant savings in lighting energy usage through the relatively easy process of substituting high-efficiency for standard efficiency lighting equipment components, ***the market may be complacent or even "spoiled" by the ease of obtaining previous improvements***.
- Because rebates were widely used to subsidize substitution with efficient components, ***the C&I lighting market may "expect" that rebate-based solutions*** will be employed by program administrators to bring about the next level of efficiency improvements in this market.
- Last, because the bulk of the C&I lighting market interventions in the 1990s focused on like-for-like equipment substitution, ***many rebate programs provided little of the groundwork***

[20] For evidence of this transformation, for example, Section 5.4 of this report and *PG&E/SDG&E Lighting Market Effects Study*, prepared by XENERGY Inc for the California DSM Measurement Advisory Committee, July, 1998.

needed to bring about the many design-based improvements in lighting that represent the bulk of the opportunity for further improvements.

7.1.2 Barriers to "Next Level" Lighting

In addition to the challenges linked to past success in influencing the C&I lighting market, there are a host of challenges inherent in the types of opportunities associated with harvesting the remaining lighting savings. This is because the greatest remaining opportunities, given technologies available today, or expected to be available in the near term, are design related, and C&I lighting design, as it turns out, is fraught with barriers to further improvement. Elsewhere in this report we have documented many of these barriers, including:

1. ***Design cost minimization***. Building developers/owners/financiers are usually unwilling to increase building budgets to accommodate the added costs of daylighting. Owners and owners and developers generally seek to minimize design and commissioning costs.
2. ***Control technology cost, ease-of-use, reliability, and reputation***. Lighting controls for daylighting are an immature market and require new products and new thinking. In the meantime, the complexity of the current products, magnified by the variations in dimming ballasts, demands much greater design costs and much greater commissioning costs. Electronic dimming ballasts are still considered to be expensive and not yet standardized by many designers. There are presently five different circuit topologies and no clear "winner." As a result, designers are reluctant to commit to specific manufacturers' technologies which, individually, have a low likelihood of staying in the market for even five years.
3. ***Lack of design/build integration (i.e., linear and fragmented design process).*** Lighting designs that make use of sunlight are stifled by the traditional linear approach to design. Most significant architectural programming is completed before the electrical engineer or lighting designer is brought on board, seriously cutting the opportunities for including daylighting provisions in the building shell plan. Furthermore, if real synergy is desired, the mechanical engineer must also participate at the early stages to provide input on actions that affect heating and cooling loads.
4. ***Pervasive lack of professional knowledge***:
   - ⇒ Electrical contractors are generally unfamiliar with dimming and daylighting technology and prefer to avoid them. Electrical contractors *perceive* these new systems as an order of magnitude increase in warranty service and call-backs. These contractors may deliberately seek to remove dimming systems, often under the guise of "value engineering." Contractors in our study also cited concerns over reliability, maintenance and customer override as significant barriers to their use of occupancy sensors.
   - ⇒ General contractors are extremely conservative and risk averse, e.g., a market actor for whom "all skylights leak."

⇒ Architects tend to be poorly trained in the proper design of daylight buildings and, as noted previously, generally do not consider lighting systems in their purview.

5. ***Use of rules of thumb and templates dominate****.* As shown in Section 5, designers report using hand calculations and rules of thumb most often to lay out fixtures, though they do not report using templates as much as hypothesized.

6. ***Lack of end-user demand for advanced lighting design and daylighting***. This hypothesis was confirmed in this study, as electrical engineers, architects, and lighting designers stated that they were asked by their clients in only 2½ percent of cases to include daylighting in their designs. Despite recent advances in documenting the energy and non-energy benefits of daylit buildings, the message has not yet effectively penetrated and affected the key end user decision makers.

7.1.3 Momentum Supporting "Next Level" Lighting

As will be discussed throughout Section 7.2, which presents our recommendations for initiatives the Alliance should consider, there are a number of positive trends in the lighting market which provide a somewhat supportive basis for efforts to achieve further reductions in C&I lighting consumption. Although these trends may not completely balance out the challenges outlined in Sections 7.1.1 and 7.1.2, they are important foundations upon which the Alliance may be able to build. These trends include the following:

- There is a ***small vanguard of "first wave" lighting designers*** (including some architects) who are defining and demonstrating best practice lighting design that includes the use of advanced controls and daylighting. The body of work being developed by this group provides a critical proof-of-concept basis for case studies that can then be to disseminate the success of best practice approaches to other practitioners, building owners, and building occupants.
- As noted in Section 5 and, again, discussed later in Section 7.2, ***many lighting professionals are interested in the use of daylighting and other advanced design practices***. These professionals are receptive to training and acknowledge their current limitations.
- ***Green buildings are the subject of increasing discussions and actions*** among government agencies responsible for building construction, building professionals, and a growing niche of environmentally minded businesses. High efficiency lighting can provide a critically important contribution to the sometimes difficult task of meeting green building certification criteria.
- Last, ***there are a number of assets already developed both in the Pacific Northwest and the rest of the United States upon which the Alliance can build*** to deliver effective lighting initiatives. These include the Lighting Lab in Seattle, regional utility energy-efficiency programs, and lighting initiative materials developed by utility and market transformation organizations outside of the PNW.

7.1.4 Philosophical Considerations

With the context provided above, we now proceed to discussing our general philosophy about how the Alliance should approach improving the current C&I lighting market.

Establish A Realistic High-Level Goal And Timeline. The Alliance should have a clear, overall goal in mind before embarking on specific initiatives in the C&I lighting market. For example, the Alliance may want to target a 15 percent improvement in total regional lighting use over current standard practice. We believe that taking the C&I lighting market to the next level will likely take five to fifteen years. As it took about five years to significantly transform the electronic ballast market, it will likely take closer to the high side of this estimate to change design and control practices.[21] However, if the goal is achieved, the energy and, importantly, the non-energy benefits to the region will be impressive. We emphasize this because it will be equally important for both the Alliance and the market actors it seeks to influence to recognize that the transformation sought will not be accomplished through "quick fixes." Rather, change will likely occur through a measured, multifaceted, and sustained approach. Related to these points, the Alliance should consider building upon the first-step market research results presented in this study by developing a theory of market change that prioritizes among the barriers identified and hypothesizes a sequence of interventions and concomitant market effects that ultimately leads to transformation.

Take A Measured Approach To Developing New Initiatives. Because it will be difficult to reduce the market barriers discussed in this report, we believe that a *measured* approach to changing the market is needed. In the short term, trying to rapidly intervene in the market with one or a combination of large initiatives could be dangerous for several reasons. First, the current generation of lighting programs aimed at moving the market to the next level (see Section 7.3 below) have only been on the streets a short time and none have shown themselves to be short-term silver bullets. Second, the enabling technologies for the next revolution in lighting design and integration are still nascent. The history of energy-efficiency program evaluation clearly shows that pushing nascent technologies too fast can have significant and long-lasting counterproductive effects. The key is to develop positive experiences in the market by leveraging the capabilities of market leaders.

Despite our admonition to avoid going "too fast", note that "measured" should not be interpreted as "go slow." As discussed in Section 6 of this report, there is no shortage of opportunities to improve the current state of lighting design. In addition, the nature of the barriers warrants assertive, creative responses. Although current penetration of daylighting and other advanced lighting approaches is low, key market actors in this study expressed optimism over the prospects for growth in these opportunities in the future (see Section 5). This suggests that despite some significant barriers, there is some "ripeness" in the market for change.

[21] However, the pace of change could be significantly affected by more rapid improvements in the costs, capabilities, and reliability of lamp, ballast, and control technologies than currently anticipated.

Get Direct Market Actor Feedback And Thoroughly "Road Test" Prospective New Initiatives. The Alliance has shown itself to be a national leader in developing, testing, assessing, improving, and culling energy efficiency programs. We applaud this and suggest that the Alliance continue its general approach and orientation to program development as it tackles the C&I lighting market. In particular, the significance of the barriers warrant a step-by-step approach that starts with obtaining direct feedback and input from the market actors the Alliance seeks to influence. Most of the initiatives to consider presented in the next section would benefit from pre-rollout presentation to affected market actors and thorough road testing at a pilot or small scale.

Mix And Match Cross-Market And Target-Market Programs And Messages. Although we have not picked which of the suggested initiatives the Alliance should pursue, we believe that a combination of initiatives that address both general and specific market barriers will be necessary. In particular, a combination of increasing demand from end users/building owners and improving product/practice supply is critical. At the same time, a diversified approach must be balanced against spreading resources too thin across too many elements. The Alliance should probably pick specific market targets within the vast world of C&I lighting, e.g., focus on the high-end or low-end but do not spread resources across both until a sufficiently diverse approach has been demonstrated (i.e., an approach that addresses most key barriers).

Leverage The Good Work Of Others And Fill Gaps Selectively. As shown in Section 7.3, there is a small renaissance of activity around the country aimed at bringing C&I lighting to the next level. This is promising and provides an excellent platform upon which the Alliance can build its own complementary and region-specific programs. A cautionary note is that most of these initiatives have been in existence only a short time and, as such, do not yet have a body of evaluation results available to demonstrate their efficacy and to improve their approaches.

Make Buying Quality Efficient Lighting More Of A Commodity Purchase. For the low-end market, but also for higher-caliber designers, explore the extent to which efficient, quality lighting can become routine, through use of standard methods, templates, equipment standards, quality guidelines and other tools. Equally importantly, create labels to help customers identify standard approaches and levels of quality for lighting (as evidenced by adherence to standards, guidelines, etc), and work with trade allies to market those labeled products. Given the profusion of guidance in the high-end market of design aids, it may require some alliance-building among trade allies to gravitate to commonly acceptable tools, and significant promotion to "cut through the clutter" and present potential consumers with a clear picture of a preferred, off-the-shelf approach. Emphasis on non-energy benefits (productivity, sales, image, etc.) will be important to help motivate customers to buy. For the most creative end of the design profession, designing prestige unique buildings, this standardized approach may not be effective with respect to design. However, even high-end designers want more standardization in equipment options and control approaches.

7.2 NEW INITIATIVE CONCEPTS FOR CONSIDERATION

In this subsection we present a list of initiative areas for the Alliance to consider. Within the scope of this study, we have not prioritized among these considerations. To prioritize among them requires estimation of the costs and benefits of carrying out each of the initiatives. This information could be developed independently through additional research or through a competitive bidding process in which bidders are required to forecast and commit to specific milestones and impacts, or through a combination of both.

Lighting Design Tools. Development and Dissemination of Lighting Design Guides, Software Tools, and Templates. This is currently a popular area of emphasis among lighting programs nationally. In fact, there is now an almost overwhelming array of design guides currently available or under completion. Regional, state, or utility-based initiatives that include design guides include, but are not limited to, the Energy Center of Wisconsin's Daylighting Initiative, the Design Lights Consortium in the Northeast, California's Savings by Design, and the New Building Institute's Advanced Lighting Guidelines (out currently in draft). In addition to these guides, advanced software and simulation tools are also being developed, particularly under California's Daylighting Initiative, such as DESKTOP RADIANCE, SkyCalc™, eQUEST™, and eVALUator™. (We note here that the Lighting Design Lab currently offers some of these services.[22])

As corroborated by our research in the PNW, efforts to date have been addressing the fact that designers, distributors and installers currently lack the knowledge and tools necessary to confidently and cost-effectively deliver high-efficiency lighting designs of the type characterized under Opportunities Number 1 and Number 2 in Section 6. The progress that has been made in developing the guides and software now available is laudable. It is important to note, however, that these guides have not been in the field long and there is little information currently available on how well they are penetrating and affecting particular market actors.

Some experts believe that the bulk of the current suite of guides and software tools are more appropriate for the "high" end of the supplier market than the "low" end. That is, these tools tend to be glossy and oriented toward describing design principles and approaches that are likely to play well with architects, electrical engineers, and lighting designers involved with large projects or employed at image-conscious firms. There is concern that the current suite of tools are not as well tailored to the smaller new construction and renovation/remodel market events for which electrical engineers, contractors and even distributors play a layout and specification role. These projects often have very small design budgets. We know that many lighting designs are developed through rules of thumb, hand calculations, or templates. One suggestion that has come up in several of the brainstorming sessions held to support

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[22] For example, the Lab assists the PNW building design community in their efforts to daylight buildings by offering access to daylighting information and the tools for assessing daylighting design decisions. The Daylighting Lab has an overcast sky and heliodon sun simulators, and digital photographic and light flux metering equipment for the analysis of physical models. In addition, the Lab allows designers to try various lighting design software programs to aid in their selection process.

this aspect of our research is to ***develop a set of best practice lighting design templates that would support the "lower" end market events and market actors***.

Because no single template, even by building type, will cover the multitude of situations that these designers face, such a set of templates would have to cover a wide variety of space configurations, building orientations, window/wall area combinations, etc. One suggestion worth investigating is to develop a multitude of best practice templates that fit the bulk of configurations likely to be encountered in the market through the power of computer simulation. This is not to say that the designer would use the computer tool itself, but that existing tools would generate a large number of fixed plans which a designer would then have in a workbook. Based upon the answers to a handful of questions that characterized the space encountered, the designer would be directed to the specific best practice template for the situation.

The crux of our recommendation here is four-fold. First, there are plenty of excellent high end design guides currently available. The Alliance should monitor the success of the various high-end guides and decide if one or more should be adopted or adapted to the PNW. The Alliance should be able to adopt or adapt for relatively low cost given the current availability of these products. Second, with respect to the high-end software tools, the Alliance should also monitor the relative success of these efforts, especially the extent to which target market actors are using and ultimately willing to pay for these tools. There appears to be a need for further development and funding of such software tools. It appears unnecessary for the Alliance to fund its own software tools as, by definition, the tools will likely be useful to designers nationally. The Alliance should consider contributing, along with other sponsor organizations around the country, to those software tools that have the most likelihood of success. Third, as noted above, the Alliance should consider co-developing best practice lighting design templates that target the lower end of the design market (this could be especially beneficial to the eastern region of the PNW where jobs tend to be smaller and contractors and distributors have more involvement in lighting decisions). We say "co-developing" because, again, these templates would likely cover a variety of configurations that would benefit multiple regions of the country, although some customization will likely be necessary to account for regional variation in daylight characteristics.[23] (It should be pointed out that the Design Lights Consortium KnowHow series is the one set of tools oriented toward [or at least intended for] the low end.) The fourth and last element of our recommendations in this area concerns not development of tools but their effective dissemination. If the Alliance decides that existing design guides can be cost-effectively adapted to the PNW, then it may want to focus on ensuring that the guides are effectively disseminated to the target market actors (after regional "road testing").

Development and Dissemination of Case Studies. This is another area, like the one discussed above, in which a great deal of progress has been made recently around the country. Most of the

[23] There was a reference at the ACEEE informal session, summarized in Appendix A, to work being done by Southern California Edison's Radiant Space Simulation study on similar contractor worksheets. A follow-up should be made with SCE to investigate this further. It was also suggested that researchers begin to ask how often lighting contractors use computers or software for their jobs (information designers' use of computer tools is provided in Section 5 of this report).

initiatives for which there are high-end design guides also are developing case studies. These case studies tend to be region specific, which is appropriate. The Lighting Design Lab also provides some case studies to visitors, as does the "Field Studies" portion of the BetterBricks.Com website. PNW utilities may also have their lighting-related case study publications. The Alliance should assess whether the current set of case studies, and associated dissemination mechanisms, from these sources are adequate to meet the region's need.

One issue raised by a manufacturer attending the ACEEE informal session (see Appendix A) is that, despite the fact that there are a number of case studies developed by utilities and regional organizations, these are not easily accessible to manufacturers and other market actors. In particular, it was noted that national manufacturers would benefit from a central repository of case studies that integrates all those currently available and organizes them geographically, by application, building type, equipment manufacturer, product type, testimonials/references, etc. The Alliance may want to ***support such a service, likely web-based, along with other lighting initiative sponsors around the country***. Also, a quick web investigation by the authors of this study appeared to indicate that there is no clear central repository of PNW advanced lighting case studies currently available. The Alliance may also want to ***consolidate and add to existing case studies for the PNW*** and ***provide a one-stop shop*** for those seeking this information and actively promote case studies to market actors throughout the region.

Finally, case studies should be carefully engineered for specific audiences and purposes. For example, different documents are needed to help contractors execute high-quality lighting projects than those targeted to the property managers to whom the contractor attempts to sell. Thus, case studies need to be carefully tailored to each key market actor (e.g., designers, owners, occupants, distributors, contractors, etc.).

Stimulation of End User/Building Owner Demand, Support for Non-Energy Benefits Demonstration Research, and Leveraging of Growing Interest in Green Buildings. Although we do not believe there are any silver bullets currently available to rapidly increase end user and building owner demand for best practice lighting, we believe that, ultimately, this is perhaps the most critical dimension of the problem. As we have stated in related market transformation studies and publications: *end users are the demand engine upon which virtually all self-sustaining changes in the marketplace are dependent*. Although this fact is relatively self-evident, it is important to keep in mind that reducing end user market barriers, and thereby increasing demand for high-efficiency products and services, provides critical stimulation to the market-based reduction of supply-side barriers. For example, we and others have identified fragmentation among specialties and the linear nature of the design process as critical barriers to greater penetration of best practice lighting designs. However, this barrier would likely solve itself if end users and building owners demanded the most efficient and productive lighting designs cost-effectively possible. Therefore, it is extremely unlikely that the fragmentation and design process barriers can be solved independently of increasing demand - these barriers exist for a reason within the current market equilibrium for buildings.[24]

Thus, we view increased end user and building owner demand as a linchpin of long-term success in increasing the penetration of the lighting technologies and practices identified in Section 6 of this report. But how to do this? Perhaps the favored approach to this problem as it pertains to C&I lighting is currently demonstration and communication of the non-energy benefits of daylighting and advanced lighting design, especially those that pertain to productivity increases. The arguments in favor of this approach are certainly powerful and the fruits of initial efforts to quantify these benefits are now being to be born.[25] Both the New Buildings Institute and Light Right Consortium are engaged in quantitative research on the non-energy benefits of lighting.

The Alliance supports, in principal, the Light Right Consortium's Phase II effort to research the suspected link between the lighted environment and human and business benefits. The Phase I research from this effort demonstrated that lighting was "on the radar screen" of concerns of senior managers about the built environment but that cost control, space planning, and occupant satisfaction were at the top of these decision makers lists.[26] This research also hypothesized that links to productivity and occupant satisfaction would be critical to capturing attention and investment for advanced lighting. To complement the approach of trying to quantitatively measure outcomes associated with advanced lighting***, the Alliance should also consider "impressions" research***, where potential buying and rental agents are asked to give impressions of similar spaces with quality and standard lighting designs. This research would likely be less costly and more quickly available than some of the quantitative studies now being launched, though also more qualitative and perhaps less influential.[27]

We believe that the above research is on the right track and should be continued and supported. A key issue, however, is whether to wait, probably years, for additional quantification of benefits, or to proceed with efforts to convince end users and owners of these benefits now. Through the Alliance's Betterbrick.com initiative, the Alliance is already engaged in this process. The approach is essentially a mass market effort that aims to motivate end users, especially building occupants to visit the website and

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[24] It is, of course, as noted throughout this section, important to address the supply-side barriers in conjunction with attempts to stimulate increased demand. At a minimum, supply-side barriers must be overcome on enough individual projects to generate the case study demonstrations necessary to influence end users and building owners.

[25] See, for example: *Skylighting and Retail Sales: An Investigation into the Relationship Between Daylighting and Human Performance*, Heschong Mahone Group, August 20, 1999; and *Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance*, Heschong Mahone Group, August 20, 1999.

[26] *Lighting Quality - Key Customer Values and Decision Process*, prepared by Ducker Research for the Light Right Consortium, August, 1999.

[27] Another approach is to poll occupants to crudely assess their perceived financial benefits. For example, Skumatz, et al., [GET ACEEE CITE] provide a simplified method whereby customers are told what their projected energy benefits are and then are asked to say if the non-energy benefits are greater or smaller, and by how much. While any method of measuring perceived benefits has problems, this type of "cut to the chase" approach may work well for marketing; if the market perceived benefits are real benefits.

become educated about whether their current working environment provides the same level of utility as environments that maximize quality (energy efficient) lighting and other features. It will be important to assess whether this particular approach to stimulating demand proves to be effective**. *Another approach the Alliance should consider is focusing on real-estate invest trusts (REITs)***. These organizations own and manage a significant percentage of the commercial floorspace in the United States.[28] By reaching and influencing the largest of these organizations, a significant percentage of square footage and lighting load can be affected. Since many of these organizations are national, the Alliance may want to consider an initiative that is supported by other regional and utility sponsors. Any PNW-specific REITs that have significant market share should be targeted with a region-specific effort.

Somewhat related to the discussion above, we believe that the current growing interest in green buildings, especially in the PNW, represents an important opportunity to advance best practice lighting in the region. Despite the obvious importance of high-efficiency lighting to those of us in the industry, there is the challenge of whether lighting, by itself, can reach the threshold of capturing end user and building owner attention. An alternative, or complementary model, is to lead with a market message that addresses the efficiency/non-energy value of the entire building.[29] Green buildings, of course, emphasize environmental benefits that go beyond but include energy efficiency. Green buildings hold the potential of providing a means by which some companies can implement their genuine desire to minimize their impact on the environment and, for others, to capture the public relations benefit of trying to position themselves as good corporate or government citizens. Though likely to remain a niche market for some time, the size of this niche could be significant. In addition, green buildings also tend to be marquee buildings (e.g., corporate and government headquarters, historic sites, etc.). Thus, green buildings may diffuse best practice energy and lighting approaches through both specialty building and general communication channels more quickly than would other buildings. The Alliance should seek to ensure that green building candidates adopt best practice lighting (especially, daylighting) and that these cases be well publicized through the appropriate communication channels. In short, we believe the development of green building standards and certification programs should be watched and leveraged, since they appeal to the competitive nature of building-owning firms and the recognition of accomplishment sought by architects.

Product Catalogues and Guides/Distributor-based Initiatives. The areas discussed above are mostly design related and they target most of the key market actors with the exception of distributors and manufacturers. Another area that the Alliance should consider is the promotion of high-efficiency lighting products at the distributor level of the value chain. Although basic high-efficiency components are now generally available from most distributors (e.g., electronic and even dimming ballast, T8 lamps, and CFLs), some of the higher end efficiency products are not well stocked or promoted at the wholesale level. As noted in Section 6, these include:

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28 See, for example, Parker, Gretchen, Mark Chao, and Victoria Gamburg, "Market Opportunities for Energy Service Companies Among Real Estate Investment Trusts," 10th National Energy Services Conference, Association of Energy Service Professionals, Tucson, December, 1999.

29 See, for example, Johnson, Jeff, and Steve Nadel, "Commercial New Construction Programs: Results from the 90s," ACEEE 2000 Summer Study Proceedings, Panel 4, August, 2000.

- Halogen IR sources
- High efficiency generic fluorescent fixtures
- T5 and T5HO fluorescent luminaires
- Modern metal halide lamp/ballast systems
- Modern industrial fluorescent systems

The overwhelming majority of lighting products flow through distributors on their way to being installed in buildings. This level of the value chain represents an important potential leverage point in the market for three reasons. First, as shown in Section 4, there are fewer distributors than contractors and designers, which means that these firms can be reached with more focused outreach than that required for contractors and designers. Second, distributors carry products from multiple manufacturers, thus, they need not be tied exclusively to particular products. Third, as reported in Section 5.8, 37 percent of contractors named distributors as a key source of information on new lighting technologies (the third most cited source after manufacturers and trade magazines). In addition, fully 83 percent of the surveyed distributors offer lighting design and fixture layout services, 61 percent offer equipment specification services, and they specify 35 percent of all the equipment they sell.

Unfortunately, however, distributors tend to be passive rather than active market intermediaries. The first-generation revolution in lighting components in the 1990s did have the effect of shifting some distributors from being market responders to being proactive promoters of high-efficiency lighting, however, most remain in the traditional position of "order fillers."

Initiative-based products that may be of interest and benefit to distributors include sponsorship of catalogues that feature only high-efficiency equipment, staff training, incentives to stock or temporarily buy-down costs on promising new technologies, point-of-purchase and other promotional materials, and independent product assessment guides.[30] Also, because the bulk of distributors are in SIC 5063-0000, electrical apparatus and equipment, they also carry other products that the Alliance may be interested in, or already, promoting like transformers, motors, VFDs, etc. A distributor initiative that cuts across electric products may be more effective than a lighting-only effort.

Education of Current Practitioners. As presented in Section 5.7, even the market actors most responsible for lighting design self-rated their knowledge level of daylighting-related practices between 'not very familiar' and 'somewhat familiar'. Importantly, none (out of 120 interviews) reported having expert knowledge of daylighting. Consistent with this finding, when these market actors were asked for their own suggestions of initiatives the Alliance should pursue, the most commonly mentioned areas were education, training, and codes. There tended to be a general agreement that more efficient products and practices (such as daylighting) are misunderstood by those who specify and build in the Pacific Northwest. Many respondents believe that, in order to increase demand of these services, more information and education must be undertaken. Specific activities suggested included:

[30] The Alliance's support of and access to the Lighting Research Center's Product Information Program may provide a ready source of content.

- Educate or train architects, designers, owners, developers and engineers
- Hold seminars, conferences and trade shows (for small and large cities)
- Offer continuing education credits for classes attended by students
- Require lighting training for professionals who participate in projects receiving incentives

Interestingly, several of these specific suggestions are already being engaged in by the Lighting Design Lab and most market actors report being aware of the Lab. This may indicate that although they are aware of the Lab, their familiarity with the services offered, including seminars held throughout the region, is more limited (note that about one-third of respondents report visiting or using Lab services). Additional research on the Lab is needed and currently being conducted. However, taken in isolation, our results indicate that the Lab is doing a good job of reaching its target market and that demand remains for its education- and training-related services.

Education of Future Practitioners. In addition to educating current lighting practitioners, many lighting experts and program administrators believe that to achieve long-term, lasting change in lighting design practices, fundamental improvements must be made in the academic education of architects and electrical engineers. However, there is no consensus on this issue. Some experts believe that academic training is of secondary importance to on-the-job experience and training because the commercial demands placed on practitioners make a more consistent, lasting impression on designers than academic courses. Of course, there is merit to both sides of this argument and it is another "chicken and egg" kind of market barrier, i.e., academic training is ineffective if there is not market demand, but market demand is limited by the lack of academic training. In addition to considering initiatives to support academic training, the Alliance may want to conduct new, or find existing, research that demonstrates a link between improved academic emphasis on advanced lighting design and the types of designs implemented by graduates of such programs.

Evaluate Need for Code Improvement. The Alliance recently sponsored a baseline study of nonresidential new construction practices in the PNW.[31] This study indicates that high-efficiency components, in particular, T8 lamps with electronic ballasts, metal halide, and CFLs, dominant the market, although incandescent and standard efficiency 8-foot lamps are still common. In addition, the average lighting power density of 1.17 watts per square foot was found to be 11 percent below the average LPD required by the Oregon Code and 27 percent below ASHRAE 90.1. Thus, codes appear to be doing their job effectively with respect to basic high-efficiency lighting components. However, the same study also shows that dimming and related daylighting systems were not penetrating the market as of 1998 (which we continue to confirm in our report in Section 5.7). In fact, responses to our surveys indicate there is some reason to believe that regional codes may discourage daylighting because of area restrictions and the added cost of showing compliance. Facilitating advanced design practices through energy codes is not easy, however. Further investigation into whether codes should be changed in light of the findings from this study and the Ecotope study should be conducted. The

[31] *Baseline Characteristics of the Nonresidential Sector in Idaho, Montana, Oregon and Washington*, D. Baylon et al, prepared by EcoTope for the Northwest Energy Efficiency Alliance, Draft, March 2000

Alliance currently has plans for an Energy Code Development Program that will provide ongoing support to energy code offices throughout the region. Plans for each may vary depending on the states' specific needs. This program has merit given the findings from our research.

Address/Support Research On Fragmented, Serial, and "Value Engineering" Aspects of the Building Design Process. As documented throughout this study and other studies listed in Section 2, fragmentation and serial sequencing of the building design process combined with "value engineering" often spell disaster for advanced lighting design and implementation. Our understanding of this problem is gradually increasing as more research is conducted that confirms and explores these barriers. For example, researchers at Washington State University are focusing on in-depth observation and analysis of the relationships between market actors involved in the building design process that may illuminate improved understanding of both the contractual and social basis for how decisions are made and "unmade" during this process.[32] The Alliance is contributing to this research effort, which should help it to mature and yield important benefits for program design and marketing strategies. We concur with the Alliance's support and encourage it to consider additional research as benefits are demonstrated.

Facilitate Regional and Inter-Regional Program Cooperation and Manufacturer Outreach. ***Leverage/Expand Utility Program Efforts***. A brief review of PNW utility websites indicates that there are a number of lighting and new construction programs in place throughout the region. If the Alliance has not already, it should compile all of the PNW utility program information that affects C&I lighting. Through this compilation, a picture of the region's utility C&I lighting programs can be developed which would then facilitate an analysis of regional consistencies, inconsistencies, and gaps. Additional research could yield an assessment of which utility programs are working well and which are not. These efforts would provide important context for the Alliance in making its next round of decisions about which, if any, regional lighting initiatives to develop.

Besides working with PNW utilities to develop initiatives that complement existing utility programs, the Alliance may want to encourage these same utilities to explore ways in which they can support the Alliance by modifying these programs or developing new ones. For example, several utilities may be providing incentives for lighting power density levels that exceed code but do so in significantly different ways. If the Alliance were to develop a set of design templates that beat code in a pre-approved way, then local utilities might provide incentives for these designs in a consistent way throughout the region. A further synergy could be achieved if code officials guaranteed accelerated approvals of the design templates. Thus, local utilities may want to capture the resource benefits of best practice lighting by developing financial incentives and other efforts that tie into the Alliance's market transformation activities.

[32] The first phase of this research was documented in Lutzenhiser, Loren and Rick Kunkle, New Commercial Buildings Market Transformation Research Needs: A Scoping Report Prepared for the California Institute for Energy Efficiency, Washington State University, September, 1998. The second phase, which will include results from observance of actual design processes, is currently in progress.

Finally, in addition to its obvious role as a regional program facilitator, developer and integrator, the Alliance may also want to consider taking a leadership role in developing or supporting national lighting initiatives. As discussed earlier in this section, there are a number of similar initiatives occurring in regions throughout the country. Some of these efforts could benefit from consolidation or increased coordination, perhaps by an entity like the Consortium for Energy Efficiency, or by a region that voluntarily takes the necessary initiative. Perhaps more importantly, there are also prospective national initiatives which have not yet been developed at all or are languishing for lack of a champion. (For example, the manufacturer that developed the National Dimming Initiative states that they have been trying to get other manufacturers to join the effort but, so far, without success. Obtaining the sponsorship of the Alliance and other program administrators and coordinators may provide the independent endorsement necessary to make this a multi-manufacturer collaborative.)

7.3 CURRENT LIGHTING INITIATIVES IN THE UNITED STATES

As background references to the discussion in Sections 7.1 and 7.2, we provide two tables in this subsection. In Table 7-1, we provide a summary of selected lighting initiatives currently being implemented throughout the United States. In Table 7-2, we provide a summary of existing or recent Alliance initiatives relevant to C&I lighting.

Table 7-1
Summary of Selected Lighting Initiatives Nationally (Source: Adam Hinge, Independent Consultant)

/ Organization/Website	Description	Primary Audience	Focus	Major Funders
Design Lights Consortium (DLC)				
www.designlights.org	A regional collaboration seeing to influence naturally occurring lighting events toward efficient, high quality lighting design	Commercial Lighting Specifiers & Decision-Makers	Northeast	NEEP, EPA and Northeast regional electric utilities
Energy Center of Wisconsin—Daylighting Initiative				
www.daylighting.org	To make successful daylighting part of mainstream construction	Designers, building owners	Wisconsin, but broadening	WI utilities, WI government
Energy Efficient Lighting Association (EELA)				
www.eela.com	To promote the purchase and installation of energy efficient lighting products through education and networking across these channels (manufacturers, distributors, contractors, ESCOs, and end-users)	Lighting industry	National	Manufacturers, Energy Efficient Lighting Service Companies (EELSCo), Energy Contractors (ECONs)
Illuminating Engineers Society of North America (IESNA)				
www.iesna.org	To advance knowledge and disseminate information for the improvement of the lighted environment to the benefit of society.	Designers	National	Membership: designers, manufacturers, et al.
Industrial Electric Contractors (IECI)				
www.ieci.org	Trade Association of non-union electrical contractors	Anyone who could effect their membership, business	National	Members (contractors)
Lighting Design Lab (Seattle)				
www.northwestlighting.org	Works to transform the Northwest lighting market by promoting quality design and energy efficient technologies.	Designers	Pacific NW	NW EE Alliance, NW utilities & governments, DOE

/ Organization/Website	Description	Primary Audience	Focus	Major Funders
Light Forum				
www.lightforum.com	Resource center and reference library for the lighting industry.	Lighting Professionals	National	Architectural Lighting Magazine LightFair International IALD Lighting Research Center inter.Light National Lighting Bureau The Lighting Design Lab Northwest Energy Efficiency Alliance
Lighting Research Center (LRC)				
www.lrc.rpi.edu	Conducts, and disseminates, applied research, development and demonstration projects to encourage the use of more efficient lighting systems and strategies	Lighting Professionals, Policy-makers, Manufacturers, End-users	National	Utilities, DOE, EPA, manufacturers
Light Right Consortium				
	To quantify ancillary benefits of quality energy-efficient lighting thereby providing significant incentive for its implementation, and to deliver this information in a form which is easily useable by the sponsors	Lighting decision-makers	National	EPA, DOE, utilities, manufacturers
National Certification Qualified Lighting Professional (NCQLP)				
www.ncqlp.org	To certify lighting professionals, thereby promoting the general well-being of the public through effective and efficient lighting practice	Lighting Professionals	National	EPA, DOE, IES, IALD, California Energy Commission
National Dimming Initiative				
www.advancetransformer.com	To raise end user occupant awareness regarding lighting controls benefits, and to simplify the selection process for the engineering community	End users, lighting designers, and electrical engineers	National	Controls manufacturers, led by Advance Transformer Company

/ Organization/Website	Description	Primary Audience	Focus	Major Funders
National Electric Manufacturers' Association (NEMA)				
www.nema.org	Represents the interests of electro-industry manufacturers. Its 550 member companies manufacture products used in the generation, transmission and distribution, control, and end-use of electricity	Anyone who could effect their membership, business	National	Manufacturers
National Electrical Contractors Association (NECA)				
www.necanet.org	Trade Association of union electrical contractors	Anyone who could effect their membership, business	National	Members (contractors)
National Lighting Bureau (NLB)				
www.nlb.org	To educate lighting decision-makers about the bottom-line benefits they can derive for their organizations-whether industrial, commercial, retail, or institutional-by specifying High-Benefit Lighting	Lighting Decision-Makers	National	Industry, government
New Building Institute, Inc. (NBI) Advanced Lighting Guidelines				
www.newbuildings.org	Develop Guidelines to describe state-of-the-art lighting technologies and design principles	Lighting Decision-Makers, Designers, Policy-Makers, and Educators	National	California Energy Commission, EPRI, Iowa Energy Center, NYSERDA, PG&E, SDG&E, SCE
New Building Institute, Inc. (NBI) PIER Program				
www.newbuildings.org	Research program that investigates daylighting and productivity in schools, offices, retail and manufacturing; and integrated ceiling/lighting /skylighting systems; and assesses outdoor lighting.	Policy-makers, Lighting Decision-Makers, Codes Organizations	California	CEC
New York Energy $mart SM				
	Increase promotion and delivery of effective, energy-efficient lighting for small commercial spaces through dissemination of tools, guidelines, incentives, and an information campaign.	Electrical contractors, lighting suppliers (Small Commercial Lighting Program)	New York	New York System Benefits Charge funding

/ Organization/Website	Description	Primary Audience	Focus	Major Funders
Pacific Gas and Electric Company (PG&E) Daylighting Initiative				
www.pge.com/pec/daylight	PG&E seeks to lower barriers to the implementation of daylighting strategies in new construction and building renovation.	Architects/ Lighting Designers	California	PG&E

Table 7-2
Alliance-Related Initiatives

Initiative	Brief Description
Lighting Design Lab	The Seattle-based Lighting Design Lab promotes energy-efficient lighting in the Pacific Northwest. Under this Alliance venture, the Lab is targeting: lighting specifiers for the retail, office, daylighting and residential sectors; colleges and trade schools for training students; trade allies, professional organizations, and Northwest utilities for partnerships; and increased marketing, advertising and electronic media regionwide.
Lighting Research Center (support)	The Alliance has agreed to join the Lighting Research Center's Partners Program, which gives the Alliance and its partners access to the New York-based center's expertise, information services, technical resources and research/development efforts. This membership will also enable networking opportunities with other LRC partners such as utilities, governments and corporations. The Alliance has also signed up for LRC's Product Information Program, which provides extensive reports on the performance of specific lighting products and designs.
Commissioning Public Buildings in the Northwest	The integration of commissioning - the process of testing and maintenance that enables building operating systems to run as they were designed - into Northwest state and local government buildings is the focus of this venture. The project includes training, education initiatives, case studies, enhanced development of commissioning services and communications to public-facility officials on the many benefits of commissioning building systems. The purpose, within each state, as well as regionally, is to encourage government support for commissioning through policies as well as practice.
BetterBricks.com	Betterbricks.com demonstrates the link between people, places and business productivity. The web site provides business owners, employees, management and the general public with information supporting the idea that "great work happens in great environments." The site also provides tools and resources that encourage people to act on this idea.
Architecture & Energy (A&E Design Awards)	Through an awards program as well as regional workshops and other educational efforts, this project helps inform the people who design commercial buildings about the value and benefits of energy-efficient architecture.
Northwest Lighting On-Line (Northwestlighting.com)	Targeting the commercial lighting market, this project offers Internet access to lighting design resources, primarily for lighting specifiers and contractors. It includes development of a Northwest lighting Web site along with energy-efficient lighting design features and product search tools on existing Web sites.

Initiative	Brief Description
Building Operator Certification	Building operators receive training in energy-efficient practices and technologies under these coordinated programs offered in Washington, Oregon and Idaho. Those who successfully complete a training series earn certification are able to reduce energy and resource consumption in the facilities they operate.
Energy Ideas Clearinghouse (EnergyIdeas.org)	The Energy Ideas Clearinghouse provides a range of information services, primarily designed for people who make energy-related decisions for businesses, industries and governments. The Clearinghouse is designing an integrated, tiered system of Internet-based resources (including a product database and on-line technical solutions), targeted projects and customized technical assistance.
Efficient Buildings Practices Initiative	This three-year project seeks to improve energy-efficient building practices in homes and commercial structures around the region, and to develop self-sustaining energy efficiency support programs and organizations.
Northwest Energy Education Institute	Energy efficiency training and education are conducted through the Northwest Energy Education Institute based at Lane Community College in Eugene, Oregon. The institute provides customized training for energy professionals as well as specific training in support of Alliance market transformation ventures. It also will offer an energy efficiency certification program available regionally and will promote energy efficiency curricula in Northwest community colleges.
Local Government Associations	The Alliance is working with local government organizations in the four Northwest states to promote market transformation and specific ventures among towns, cities and counties. Current tasks include recruiting water utilities for the ENERGY STAR © Clothes Washer program, marketing the Building Operator Certification program, communicating to local governments on market transformation and energy efficiency issues, and providing support for efficient building practices.

A

SUMMARY OF ACEEE INFORMAL SESSION

On August 23 of 2000, at ACEEE's bi-annual meeting on building energy efficiency, Ken Anderson of the Alliance, Mike Rufo of XENERGY, and Adam Hinge, Independent Consultant, hosted an informal session regarding the current state of the nonresidential lighting market in the United States. Nearly 40 experts attended the session, and discussion was lively. The informal venue's focus was to discern what initiatives were currently being implemented around the country, encouraging further cooperation among those initiatives, and identifying gaps in the current set of initiatives. The "gap" analysis that emerged during the discussion is summarized in this appendix.

During open discussion, many topics and issues were raised. The principal topics discussed were:

- lighting controls,
- manufacturer needs,
- targeting lighting designers of the future,
- light quality,
- fluorescent barriers,
- energy code inadequacies,
- reluctance of organizations to promote higher efficiency standards,
- fragmentation in the design process,
- promoting energy efficiency to businesses,
- lighting design tools, and
- integrated lighting design.

A summary of the statements made and issues made with respect to each of the above topics is provided in the remainder of this appendix.

A.1 ROBUST AND CONVENIENT LIGHTING CONTROLS

Although it is agreed that many advances have taken place in the lighting controls market, the group generally agreed that more advances are necessary. Lighting control systems are often out-dated, difficult to easily integrate into design, have a negative stigma, and have little available information about their performance. Guidelines are needed to characterize and specify lighting controls. Some representative comments made by individual participants in the discussion included following:

- "There is a huge frontier of energy savings to be had with lighting controls but very little information about their performance, how to get over the negative stigma regarding controls, etc."
- "Evaluate and improve controls" (e.g., improve ease of occupancy sensor installation)
- "Need to feed back field experience data on photosensor failures and successes to manufacturers. Francis Rubinstein from Lawrence Berkeley Laboratories has summarized a chapter on controls for the Advanced Lighting Design Guidelines."
- "There are fabulous buildings with advanced lighting designs ruled by archaic controls."
- "Lighting loggers help to quantify the benefits of occupancy sensors (Environmental Protection Agency's Bill Oneida, and Pacific Gas and Electric's Load Shape study have some data on this)."
- "Advanced Lighting Guidelines, Lighting Research Center, Environmental Protection Agency: occupancy sensor studies (EPA)"

A.2 MANUFACTURER NEEDS

Manufacturers of lighting equipment are in a position to promote energy efficient products, yet this is rarely done. Since customers are still buying lower efficiency products, which require less marketing, manufacturers' representatives have little incentive to promote the higher efficiency technologies.

Two manufacturer representatives at ACEEE pointed out the lack of available efficient technology case studies. Case studies are used extensively in marketing any technology, and many of the utility-sponsored projects have remained hidden from the manufacturer representatives for lack of a centralized repository. Efforts should be made, it was hypothesized, to closer relate lighting manufacturers with utility DSM program managers, who can provide credible case studies to the manufacturers and their clients.

- Need forum for dialog between utilities, regional programs and manufacturers
- National Dimming Initiative needs to attract the other ballast manufacturers. It is perceived as a Phillips/Advance initiative.
- Manufacturers lack information on dimming technologies and applications
- A central repository of standardized case studies is missing. A prerequisite of this is defining a useful case study for all industry partners.
- Unbiased source of information on lighting technologies, widely available and accessible to customers. A comparison to Consumer Reports was made.

On the issue of case studies, a manufacturer at ACEEE reported knowing of major end users who would like to use dimming ballasts and controls but they need the reassurance and accessibility of local case studies. The industry needs to find ways to reduce the perception of risk with dimming systems and the successful case study can be part of that.

Product development involves risk as well. Manufacturers are looking for ways to bring new products to market if they know they will sell in sufficient volumes to justify design, testing, production setup and manufacturing. It takes several years to bring new products to market. Long-term partnerships between utilities and regional groups with the manufacturers could help provide the assurance that a market will exist for products with long development times.

A.3 LIGHTING DESIGNERS OF TOMORROW

Since architects are the designers of buildings, educating them on daylighting and efficient lighting techniques is important. Schools and curriculums don't focus on lighting and efficiency, so providing some training would be beneficial. The target audience are the designers of tomorrow who are currently learning about how buildings are formulated. Impacting the education process before students continue to practice "business as usual" is an opportunity.

- NCQLP doing some work here.
- Also need to educate architect's clients so that these services are desired.
- Architects need to bring energy and daylighting into early conceptual shell design, especially window-to-wall ratios, building orientation, glass shading coefficients and color, skylights and clerestories, etc. They need to add the key energy design criteria to their consideration of form in the earliest stages. Visual tools both on paper and on computer, especially AutoCAD, would be helpful.
- Trend toward University training from industries/businesses
- Should the Alliance fund education?

A.4 LIGHTING QUALITY

There is a need for standardized quality indexes for lighting. In addition to ratings like footcandles and watts per square foot, a rating and guideline schedule should be introduced to assess the quality of light in a space. This rating system should be easy to understand, and allow for a variety of factors including ambiance, daylight, glare, etc.

A.5 FLUORESCENT BARRIERS

There remains a need to overcome the negative perception of fluorescent lamps from the general public. Ideas such as a national consistent marketing campaign like EnergyStar were mentioned. Better Bricks was given as an example of current practice which could encompass this task. Among end users, "fluorescent" is a dirty word, so choosing words that resonate better with audiences is a good idea. Shift the focus from technology to strategy; instead of lamps being the targeted change, have overall lower power bills be the goal.

- The A-lamp (Edison's incandescent) needs to be dropped and yet a quick poll of the room showed only a couple people with no A-lamps in their home. Cheap sells especially in areas with very low hours of operation. This may be more significant in the residential sector, however.
- Technical Procurement Program did not work (to counter incandescents).

A.6 Energy Code Inadequacies

Advanced energy codes are not currently addressing electronic ballasts and T-8 lamps (ASHRAE 90.1). Some feel codes are too restrictive, while others believe they are too lenient. Energy codes need to be upgraded; not just watts per square foot changes, but maybe requiring occupancy sensors, controls such as dimming, and technologies like electronic ballasts in areas that make sense. (The ASHRAE 90.1 Committee is looking for additional members to help revise the energy standards in buildings; including lighting.)

A.7 Reluctance to Promote High Efficiency

Some organizations are reluctant to promote high efficiency standards. A case in point was NEMA's perception of 34 watt lamps and efficient magnetic ballasts as “high efficiency.” This is two generations behind what is available and accessible right now. Raise the standards on what constitutes “efficient.” Too many groups feel that EPACT has met all of the needs for energy efficiency that it set out to do.

- EPACT: provision for energy centers in more areas to change the market.

A.8 Fragmentation of Lighting Professionals

Fragmentation in the design and installation process is a major hurdle to creating more use and demand for advanced lighting systems. Architects, engineers and other components of a design team need to better synthesize their specialties for producing effective lighting design; especially for daylighting and advanced control systems. Reaching specifiers at the proper stage in the design process is key. Better research on decision-making and/or specifying practices are needed. Indicators of energy efficiency in the market between market actors should be put in place. Communication is also necessary between the design team and installers to ensure that any equipment substitutions still meet with the design intent.

A.9 Business Interactions

Work with businesses to promote energy efficiency. Large commercial companies have sound business strategies on how to implement market stimulators, so utilize their knowledge for increasing demand for efficient products.

A.10 Lighting Design Tools

Designers, distributors and dealers would like easy lighting design tools like templates and simple computer programs so they can help customers, especially the smaller ones. Architects and designers seldom have a budget to follow-up after the original design submission, so these tools must be accurate, easy to use, and quick. One suggestion was for templates which a contractor could carry onto a job-site; perhaps a few paper worksheets on a clipboard. There was a reference to work being done by Southern California Edison's Radiant Space Simulation study on similar contractor worksheets. It was also suggested that researchers ask how often contractors use computers or software for their jobs.

A.11 Integrated Lighting Design

One attendee suggested that integrated lighting design is where the Northwest Energy Efficiency Alliance should focus their initiative money. Tie lighting into the whole building performance process, and allow gut rehabs or new construction to have lighting standards buried within.

B SURVEY RESULTS

The data presented in this appendix are taken from telephone surveys performed by XENERGY staff with lighting distributors, contractors and designers during June, July and August of 2000. Results are presented by region in the Pacific Northwest and for the entire four-state region. Longitude 121.5°W is the dividing line between the East and West regions. Results are presented separately for the following market actors:

B.1 DISTRIBUTORS

Q1.1 Of the following, which best describes your firm's business?

	East	West	All
Catalog/mail order	0%	0%	0%
General industrial supplier	21%	28%	25%
Electrical equipment supplier	50%	28%	37%
Lighting supplier only	4%	25%	17%
Manufacturer representative	25%	19%	22%
Totals	100%	100%	100%
# Respondents	24	36	60

Q1.2 How would you describe your own position?

	East	West	All
General sales	0%	3%	2%
Electrical sales	0%	3%	2%
Lighting sales	33%	3%	15%
Inside Sales / Quotations	25%	22%	23%
Manager	0%	14%	8%
President/Owner	21%	42%	33%
Other	21%	14%	17%
Totals	100%	100%	100%
# Respondents	24	36	60

Q1.3a Does your company provide lighting design and specification services other than equip sales?

	East	West	All
Lighting design and fixture layout	8%	34%	24%
Equipment specification	4%	0%	2%
Neither	17%	14%	15%
Both Lighting design and equipment specification	71%	51%	59%
Totals	100%	100%	100%
# Respondents	24	35	59

Q1.3c Roughly how many C&I project did your firm work on in the last 12 months that involved design, layout, or specification of lighting equipment?

	East		West		All	
Large	175	n=1	45	n=11	56	n=12
Medium	44	n=9	17	n=11	29	n=20
Small	39	n=14	65	n=14	52	n=28

Q1.4 How many FTEs of all types do you employ at this location?

	East		West		All	
Large	40	n=1	111	n=11	105	n=12
Medium	13	n=9	13	n=11	13	n=20
Small	6	n=14	6	n=14	6	n=28

Q1.5 How old is your company?

	East		West		All	
Large	20	n=1	60	n=11	56	n=12
Medium	53	n=9	50	n=11	51	n=20
Small	35	n=14	20	n=14	28	n=28

Q1.6 Approximately what were the total revenues for your company in 1999 at this location?

	East		West		All	
Large	$10,000,000	n=1	$29,754,231	n=10	$27,958,392	n=11
Medium	$9,821,429	n=7	$3,400,000	n=5	$7,145,833	n=12
Small	$2,391,667	n=6	$2,472,727	n=11	$2,444,118	n=17
Average	$6,650,000	n=14	$13,143,935	n=26	$10,871,058	n=40

Q1.7 Approximately, what share of your company's annual revenue at this location is related to C&I lighting?

	East		West		All	
Large	25%	n=1	51%	n=9	49%	n=10
Medium	35%	n=8	53%	n=11	46%	n=19
Small	70%	n=12	74%	n=14	72%	n=26

Q1.8 What percent of your commercial lighting equipment sales are to each of the following?

	East	West	All
Contractors/builders	63%	45%	52%
End users	14%	34%	26%
Other distributors	15%	15%	15%
Retail stores	6%	3%	4%
Other	2%	2%	2%
Totals	100%	100%	100%
# Respondents	23	35	58

Q2.1 I'd like to read you a list of a several lighting technologies and I'd like you tell me whether or not you stock each one, and whether your sales volume has increased, decreased, or stayed about the same over the last 3 years.

n = 57	Sell Less	Sell Same	Sell More	Don't Stock
T-8 lamps	4%	4%	93%	0%
T-5 lamps	4%	18%	32%	46%
Electronic ballasts	0%	5%	93%	2%
Dimming electronic ballasts	0%	25%	42%	33%
Daylighting controls	2%	41%	29%	29%
Occupancy sensors	4%	32%	46%	19%
Linear pendants	2%	13%	34%	52%
Hardwired CFLs	5%	20%	57%	18%
LED exit signs	0%	5%	82%	12%
Compact MH lamps	2%	18%	60%	21%

Q2.2 What year did you begin carrying the following product types?

	East	West	All
T-5 lamps	1998	1998	1998
Electronic ballasts	1993	1992	1992
Dimming electronic ballasts	1995	1996	1996
CFLs	1991	1990	1990
Daylighting sensors and controls	1992	1991	1991
Compact MH	1995	1994	1995
# Respondents	20	30	50

Q2.3 Of all your downlight or sconce sales, what percent were compact fluorescent in 1999? And how about in 1996?

	East	West	All
1996	30%	33%	32%
1999	39%	56%	49%
# Respondents	20	29	49

Q2.4 Of all your linear fluorescent sales, what percent were T12, T8, and T5 in 1999? And how about in 1996?

	East	West	All
1996			
T12	60%	55%	57%
T8	40%	45%	43%
T5	0%	0%	0%
1996 Totals	100%	100%	100%
# Respondents	18	27	45
1999			
T12	33%	36%	35%
T8	66%	61%	63%
T5	1%	4%	3%
1999 Totals	100%	100%	100%
# Respondents	20	31	51

Q2.5 Of all your linear fluorescent ballast sales, what percent were electronic in 1999? And how about in 1996?

	East	West	All
1996			
T12	52%	60%	57%
T8	48%	39%	43%
T5	0%	0%	0%
1996 Totals	100%	100%	100%
# Respondents	18	27	45
1999			
T12	33%	32%	32%
T8	67%	67%	67%
T5	1%	1%	1%
1999 Totals	100%	100%	100%
# Respondents	22	31	53

Q2.6 What percentage of C&I lighting do you submit competitive bids?

	East	West	All
Average	83%	68%	74%
# Respondents	13	15	28

Q2.7 For the lighting equipment you sell into the commercial and industrial sector, who has the most influence in making the following decisions?

Q2.7a Specification of lighting fixtures [MULTIPLES ACCEPTED]

	East	West	All
Developer	6%	0%	3%
Owner/Tenant	6%	7%	6%
Architect	6%	40%	23%
Electrical Engineer	63%	20%	42%
Lighting Designer	6%	7%	6%
General Contractor	6%	0%	3%
Lighting/Electr Contractor	6%	13%	10%
Lighting/Electr Distributor	0%	7%	3%
Other	0%	7%	3%
Totals	100%	100%	100%
# Respondents	16	15	31

Q2.7b Placement of lighting fixtures [MULTIPLES ACCEPTED]

	East	West	All
Developer	0%	0%	0%
Owner/Tenant	0%	5%	3%
Architect	20%	15%	17%
Electrical Engineer	60%	35%	46%
Lighting Designer	0%	20%	11%
General Contractor	0%	5%	3%
Lighting/Electr Contractor	0%	15%	9%
Lighting/Electr Distributor	0%	5%	3%
Other	20%	0%	9%
Totals	100%	100%	100%
# Respondents	15	20	35

Q2.7c Decision to use lighting controls [MULTIPLES ACCEPTED]

	East	West	All
Developer	0%	0%	0%
Owner/Tenant	7%	13%	10%
Architect	0%	13%	7%
Electrical Engineer	79%	40%	59%
Lighting Designer	0%	7%	3%
General Contractor	0%	0%	0%
Lighting/Electr Contractor	7%	13%	10%
Lighting/Electr Distributor	0%	7%	3%
Other	7%	7%	7%
Totals	100%	100%	100%
# Respondents	14	15	29

Q3.4 What are the most important factors that determine which commercial lighting equipment you recommend to your customers? [MULTIPLES ACCEPTED]

	East	West	All
Initial cost of the equipment	28%	9%	17%
Total lifecycle costs / energy efficiency	12%	18%	16%
Lighting level (appropriate brightness)	16%	21%	19%
Lighting quality (color, effect on look of merchandise)	8%	24%	17%
Meeting code requirements	4%	0%	2%
Ease of lamp replacement, maintenance	12%	6%	9%
Flexibility in initial configuring	0%	0%	0%
Ease of equipment reuse / relocatability	0%	0%	0%
Other	20%	21%	21%
Totals	100%	100%	100%
# Respondents	12	16	28

Q3.5 When you attempt to sell or specify energy efficient lighting equipment, do you discuss any of the following? [MULTIPLES ACCEPTED]

	East	West	All
Comparative operating costs	83%	88%	86%
Comparative lamp life and maintenance	92%	100%	96%
Comparative lumen depreciation	75%	63%	68%
Effect of quality lighting on productivity and safety	67%	56%	61%
Lifecycle costs / payback	42%	69%	57%
# Respondents	12	16	28

Q3.6 How frequently do you find that the lighting equipment actually installed differs from the original specification on your new construction projects?

	East	West	All
Always	0%	0%	0%
Frequently	0%	38%	21%
Sometimes	23%	31%	28%
Rarely	46%	31%	38%
Never	8%	0%	3%
Don't Know	23%	0%	10%
Totals	100%	100%	100%
# Respondents	13	16	29

Q4.0 In what percentage of commercial lighting projects do you have discretion over the kind of equipment specified?

	East	West	All
Average	24%	39%	35%
# Respondents	9	21	30

Q4.1 How often do you specify the following equipment in commercial and industrial projects? [1=Often, 2=Sometimes, 3=Rarely, 4=Never]

	East	West	All
34W ES T12 Lamped Fixtures	2.7	2.6	2.6
Linear T8 Lamped Fixtures	1.3	1.2	1.2
Linear T5 Lamped Fixtures	3.0	2.9	2.9
Magnetic Ballasts	2.7	2.8	2.8
Electronic Ballasts	1.3	1.0	1.0
Dimming Ballasts	2.5	2.5	2.5
Occupancy Sensors	2.0	1.9	1.9
Indirect or I/D Pendant Fixtures	1.5	2.1	2.0
Hardwired CFL Fixtures	1.3	1.6	1.6
LED Exit Signs	1.3	1.2	1.2
Compact Metal Halide Fixtures	1.3	1.9	1.8
# Respondents	4	19	23

Q4.2 What are the reasons that might keep designers from using occupancy sensors in a design? [MULTIPLES ACCEPTED]

	East	West	All
First cost (including setup and tuning)	100%	41%	57%
Equipment reliability	0%	6%	4%
Potential for maintenance problems	0%	18%	13%
Customer's override/misuse of occupancy controls	17%	24%	22%
Commissioning/re-tuning costs	17%	12%	13%
Lack of knowledge by designers	0%	47%	35%
Power too cheap to justify payback	17%	18%	17%
# Respondents	6	17	23

Q4.3 In your opinion, what are the benefits, if any, of using daylighting in C&I buildings? [MULTIPLES ACCEPTED]

	East	West	All
Improved productivity/performance	10%	24%	19%
Increased sales (retail)	0%	5%	3%
Increased occupant satisfaction	10%	48%	35%
Reduced energy costs	90%	81%	84%
Increased building valuation	10%	5%	6%
Reduced eye strain	0%	14%	10%
Other	0%	38%	26%
# Respondents	10	21	31

Q4.4 What are all the reasons that might keep designers from choosing a daylighting design that reduces lighting energy use with dimming or other controls? [MULTIPLES ACCEPTED]

	East	West	All
First cost	71%	39%	48%
Equipment reliability	0%	6%	4%
Potential for maintenance problems	0%	17%	12%
Customer's lack of awareness of dimming controls	14%	22%	20%
Customer's lack of information about dimming controls	14%	22%	20%
Limited designer knowledge or project budget precludes daylighting design	14%	50%	40%
Other	29%	11%	16%
# Respondents	7	18	25

Q4.5 On roughly what percentage of your lighting products, if any, have you provided daylighting controls and/or dimming ballasts over the past two years?

	East		West		All	
Large	n/a	n=0	8.5%	n=6	8.5%	n=6
Medium	6.0%	n=5	4.9%	n=7	5.3%	n=12
Small	3.0%	n=5	7.1%	n=8	5.5%	n=13

***Note: These results may be inaccurate due to a small number of responses in which distributors interpreted our question to include photocell control of exterior fixtures. We found and corrected two instances of this misinterpretation, but we cannot be sure there are no others.*

Q4.7 On roughly what percentage of you lighting projects, if any, have you provided occupancy controls or lighting EMS in the past two years?

	East		West		All	
Large	n/a	n=0	33%	n=7	33%	n=7
Medium	20%	n=5	31%	n=7	26%	n=12
Small	35%	n=5	24%	n=4	30%	n=9

Q5.3 In terms of maintaining your firm's competitive position, how important would you say it is that you offer energy efficient lighting technologies? [1 = Very important, 5 = Not at all important]

	East	West	All
Average	1.4	1.2	1.3
# Respondents	22	34	56

Q5.4 What sources do you use to keep abreast of new lighting technologies? [MULTIPLES ACCEPTED]

	East	West	All
Other lighting designers	0%	9%	5%
Distributors	14%	11%	13%
Manufacturers	76%	60%	66%
Trade magazines	57%	37%	45%
Websites	10%	3%	5%
Trade shows (e.g., Lightfair)	14%	31%	25%
Northwest Lighting Lab	10%	17%	14%
PGE Lighting Lab	0%	3%	2%
Other: (Specify)	14%	31%	25%
# Respondents	21	35	56

Q5.5a Are you aware of the Lighting Design Lab in Seattle?

	East	West	All
Yes	65%	82%	75%
No	35%	18%	25%
# Respondents	23	34	57

Q 5.5b Have you ever been to the Design Lab?

	East	West	All
Yes	13%	64%	47%
No	87%	36%	53%
# Respondents	15	28	43

Q5.5c Have you ever used any of the services offered by the Design Lab?

	East	West	All
Yes	20%	64%	49%
No	80%	36%	51%
# Respondents	15	28	43

Q5.5d Which services? [MULTIPLES ACCEPTED]

	East	West	All
Consultations	0%	5%	5%
Mock-up facilities	0%	26%	23%
Classes	67%	42%	45%
Tours	33%	16%	18%
Daylighting simulations	0%	0%	0%
Other	0%	11%	9%
# Respondents	3	19	22

Q5.6a Are you aware of the PGE Lighting Lab in Portland?

	East	West	All
Yes	30%	59%	47%
No	70%	41%	53%
# Respondents	23	34	57

Q5.6b Have your ever used any of the services offered by the PGE Lighting Lab?

	East	West	All
Yes	0%	75%	56%
No	100%	25%	44%
# Respondents	7	20	27

Q5.7a Have you ever used www.lightsearch.com?

	East	West	All
Yes	35%	47%	42%
No	65%	53%	58%
# Respondents	23	34	57

Q5.7b Have you ever used any of the services offered by www.lightsearch.com?

	East	West	All
Yes	63%	56%	58%
No	38%	44%	42%
# Respondents	8	16	24

Q5.8 Would you like to participate in the lighting advisory group?

	East	West	All
Yes	65%	74%	70%
No	26%	26%	26%
Don't Know	9%	0%	4%
# Respondents	23	34	57

B.2 CONTRACTORS

SC1 Does your company...

	East	West	All
Install commercial or industrial lighting equipment	0%	29%	17%
Design, layout, and install C&I lighting equipment	8%	41%	27%
Design, layout, install and sell C&I lighting equipment	85%	29%	53%
Install and sell C&I lighting equipment	8%	0%	3%
Totals	100%	100%	100%
# Respondents	13	17	30

SC2 Is commercial and industrial lighting a significant part of your business?

	East	West	All
Yes	85%	82%	83%
No	15%	18%	17%
# Respondents	13	17	30

SC3 Does your company do more than $50,000 per year in commercial and industrial lighting work?

	East	West	All
Yes	92%	100%	97%
No	8%	0%	3%
# Respondents	13	17	30

Q1.1 Which of the following best describes your firm’s business?

	East	West	All
Electrical Contractor	92%	94%	93%
Lighting Contractor	8%	6%	7%
Totals	100%	100%	100%
# Respondents	13	17	30

Q1.2 How would you describe your own position?

	East	West	All
Designer	0%	0%	0%
Engineer	0%	0%	0%
Contractor	0%	19%	10%
Manager	38%	44%	41%
Owner	62%	38%	48%
Totals	100%	100%	100%
# Respondents	13	16	29

Q1.3 Roughly how many commercial and industrial projects did your firm work on in the last 12 months that involved installation or retrofit of lighting equipment?

	East		West		All	
Large	69	n=7	75	n=8	72	n=15
Medium	17	n=3	17	n=4	17	n=7
Small	40	n=3	12	n=4	24	n=7

Q1.4 How many full-time equivalent workers of all types do you employ at this location?

	East		West		All	
Large	81	n=7	131	n=9	109	n=16
Medium	17	n=3	15	n=4	15	n=7
Small	5	n=3	8	n=4	6	n=7

Q1.5 How old is your company?

	East		West		All	
Large	37	n=7	43	n=8	40	n=15
Medium	31	n=3	27	n=2	29	n=5
Small	14	n=3	29	n=3	22	n=6

Q1.6 Approximately, what were the total revenues for your company in 1999 at this location?

	East		West		All	
Large	$12,625,000	n=5	$7,083,333	n=7	$9,300,000	n=12
Medium	$1,775,000	n=2	$2,333,333	n=3	$2,110,000	n=5
Small	$840,000	n=2	$1,500,000	n=4	$1,280,000	n=6
Average	$6,966,250	n=9	$4,269,231	n=14	$5,296,667	n=23

Q1.7 Approximately, what share of your company's annual revenue is related to commercial and industrial lighting work?

	East	West	All
Percent	40%	39%	39%
# Respondents	13	14	27

Q1.8 Approximately, what share of your company's annual revenue is related to commercial and industrial lighting work?

	East	West	All
New Construction	45%	55%	50%
Major Renovation and Remodeling	21%	26%	24%
Retrofit of Operable Equipment	27%	16%	21%
Replacement of Failed Equipment	6%	4%	5%
Totals	100%	100%	100%
# Respondents	13	15	28

Q1.9. Approximately, what percentage of all your commercial and industrial lighting work is made up by…

	East	West	All
Offices	21%	40%	31%
Retail	25%	9%	17%
Other Commercial	37%	38%	37%
Industrial	17%	13%	15%
Totals	100%	100%	100%
# Respondents	13	14	27

Q3.1 What percentage of your commercial and industrial lighting equipment do you purchase from each of the following?

	East	West	All
Traditional Distributor	86%	91%	89%
Manufacturer's Representative	4%	1%	3%
Direct from Manufacturer	9%	7%	8%
Home Depot or similar store	1%	0%	0%
Other	0%	1%	1%
Totals	100%	100%	100%
# Respondents	13	17	30

Q3.2 Do you ever buy lighting equipment through the Internet?

	East	West	All
Yes	0%	6%	3%
No	100%	94%	97%
# Respondents	13	17	30

Q3.3a Do you ever use a distributor or manufacturer's rep to finance equipment purchases during construction?

	East	West	All
Yes	8%	24%	17%
No	92%	76%	83%
# Respondents	13	17	30

Q3.3b How often?

	East	West	All
"all the time"	0%	75%	60%
3-5% of the time	0%	25%	20%
Rarely	100%	0%	20%
Totals	100%	100%	100%
# Respondents	1	4	5

Q3.5 In what percent of jobs does the owner or architect allow you to substitute equipment?

	East	West	All
Percent	32%	65%	49%
# Respondents	13	14	27

Q4.1 In what percent of commercial and industrial jobs did you install occupancy sensors in 1999? How about in 1996?

	East	West	All
1996	9%	20%	14%
1999	18%	28%	23%
# Respondents	13	15	28

Q4.2 Of all your linear fluorescent installations, what percent were T12, T8, and T5 in 1999? And how about in 1996?

	East	West	All
1996			
T12	49%	42%	45%
T8	51%	58%	55%
T5	0%	0%	0%
1996 Totals	100%	100%	100%
# Respondents	13	14	27
1999			
T12	19%	17%	18%
T8	81%	82%	81%
T5	0%	1%	1%
1999 Totals	100%	100%	100%
# Respondents	13	15	28

Q4.3 Of all your linear fluorescent ballast installations, what percent were magnetic, electronic, and dimming in 1999? And how about in 1996?

	East	West	All
1996			
Magnetic	47%	59%	52%
Electronic	51%	41%	47%
Dimming	1%	0%	1%
1996 Totals	100%	100%	100%
# Respondents	13	14	27
1999			
Magnetic	21%	16%	18%
Electronic	77%	82%	80%
Dimming	2%	2%	2%
1999 Totals	100%	100%	100%
# Respondents	13	15	28

Q5.1 In what percentage of jobs do you specify the equipment yourself? *(instead of the electrical engineer or architect)*

	East	West	All
Total	25%	39%	33%
# Respondents	13	16	29

Q5.2 How often do you propose more energy efficient lighting options to your clients?

	East	West	All
Total	81%	79%	80%
# Respondents	12	16	28

Q5.3 On a scale from 1 to 5 where 1 is not at all important and 5 is very important, How important do your commercial customers consider the following characteristics:

	East	West	All
Initial cost of equipment	4.2	4.6	4.4
Total lifecycle costs / energy efficiency	3.1	4.1	3.6
Quality of light	3.2	3.9	3.6
Ease of maintenance	2.7	3.5	3.1
# Respondents	13	16	29

Q5.4 In terms of maintaining your firm's competitive position, how important is offering T8 lamps, electronic ballasts, compact fluorescent lamps, daylighting, or occupancy controls in your installations for existing buildings? Would you say ... [1=Very important, 2=Somewhat important, 3=Not very important, and 4=Not at all important]

	East	West	All
Average	1.7	1.6	1.7
# Respondents	13	17	30

Q5.5 In approximately what percent of cases for existing buildings do you recommend or specify T8 lamps instead of or as an option to T12 lamps?

	East	West	All
Average	69%	77%	73%
# Respondents	13	14	27

Q5.6 In approximately what percent of cases do you recommend or specify compact fluorescent lamps instead of or as an option to incandescent lamps?

	East	West	All
Average	66%	59%	62%
# Respondents	13	13	26

Q5.7 Now I'd like to talk about occupancy sensors. What are all the reasons that might keep you from recommending occupancy sensors? [UNAIDED] [Multiples accepted]

	East	West	All
First Cost	42%	29%	35%
Equipment Reliablility	33%	36%	35%
Maintenance Problems	17%	7%	12%
Customer Override/Misuse	0%	14%	8%
Commissioning/Re-tuning Costs	0%	0%	0%
Other	8%	14%	12%
Totals	100%	100%	100%
# Respondents	10	11	21

Q6.0 Are you familiar with the process of daylighting?

	East	West	All
Yes	100%	76%	87%
No	0%	24%	13%
# Respondents	13	17	30

Q6.1 What percentage of your lighting projects have you installed daylighting controls and/or dimming ballasts over the past two years?

	East	West	All
Average	4.9%	3.3%	4.0%
# Respondents	12	17	29

Q6.3 What do you think are the biggest hurdles to keeping daylighting from being used more? [DO NOT PROMPT] [Multiples acceptables]

	East	West	All
Fragmentation of specialties	17%	17%	17%
Climate too cloudy	4%	4%	4%
Extra equipment cost	29%	17%	23%
Extra labor cost	8%	13%	11%
Glare problems	0%	0%	0%
Thermal compromise (overheating or cooling)	4%	0%	2%
Need for follow-up maintenance and re-tuning	0%	9%	4%
Lack of knowledge with designers	33%	30%	32%
Other	4%	9%	6%
Totals	100%	100%	100%
# Respondents	13	13	26

Q6.4.1 What are all the reasons that might keep you from recommending a daylighting design that reduces lighting energy use with dimming or other controls? [UNAIDED]

	East	West	All
First Cost	42%	42%	42%
Equipment Reliability	0%	8%	4%
Potential for Maintenance Problems	0%	0%	0%
Customer Lack of Awareness of Dimming Controls	17%	8%	13%
Customer Lack of Information of Dimming Controls	17%	8%	13%
My own lack of experience	25%	33%	29%
Other	0%	8%	4%
Totals	100%	100%	100%
# Respondents	11	13	24

Q6.6 How interested, if at all, would you say your firm is in doing more work with daylighting systems? Would you say... [1=Very interested, 2=Somewhat interested, 3=Not very interested, or 4=Not at all interested]

	East	West	All
Average	1.7	1.7	1.7
# Respondents	13	10	23

Q7.2 What sources do you typically use to keep abreast of new lighting technologies? [UNAIDED]

	East	West	All
Other lighting contractors	0%	0%	0%
Architects	9%	0%	4%
Distributors	27%	38%	33%
Manufacturers	64%	31%	44%
Trade magazines	64%	75%	70%
Websites	0%	6%	4%
Trade shows (e.g. Lightfair)	18%	6%	11%
Northwest Lighting Lab	0%	13%	7%
PGE Lighting Lab	0%	0%	0%
Other	27%	38%	33%
# Respondents	11	16	27

Q7.3a Are you aware of the Lighting Design Lab in Seattle?

	East	West	All
Yes	62%	56%	59%
No	38%	44%	41%
# Respondents	13	16	29

Q7.3b Have you ever been to the Design Lab?

	East	West	All
Yes	33%	44%	39%
No	67%	56%	61%
# Respondents	9	9	18

Q7.3c Have you ever used any of the services offered by the Design Lab?

	East	West	All
Yes	88%	86%	87%
No	13%	14%	13%
# Respondents	8	7	15

Q7.3d Which services have you used? [Multiples accepted]

	East	West	All
Consultations	29%	10%	18%
Mock-up facilities	0%	20%	12%
Classes	43%	30%	35%
Tours	0%	0%	0%
Daylighting Simulations	0%	20%	12%
Other	29%	20%	24%
Totals	100%	100%	100%
# Respondents	6	6	12

Q7.4a Have you ever used the web site www.lightsearch.com?

	East	West	All
Yes	8%	6%	7%
No	92%	94%	93%
# Respondents	13	17	30

Q7.4b Have you ever used any of the services offered by the www.lightsearch.com?

	East	West	All
Yes	0%	100%	50%
No	100%	0%	50%
# Respondents	1	1	2

B.3 DESIGNERS

SC1. Does your company

	East	West	All
Design or layout C&I lighting	92%	94%	93%
Install commercial or industrial lighting equipment	8%	0%	3%
Design, Layout and Install C&I lighting equipment	0%	6%	3%
Totals	100%	100%	100%
# Respondents	12	18	30

SC2. Is commercial and industrial lighting a significant part of your business?

	East	West	All
Yes	100%	89%	93%
No	0%	11%	7%
# Respondents	12	18	30

Q1.1 Of the following, which best describes your firm's business?

	East	West	All
Architectural	17%	33%	27%
Electrical contracting	0%	6%	3%
Lighting contracting	0%	0%	0%
Lighting wholesale/distributing	0%	0%	0%
Electrical engineering	33%	28%	30%
Consulting engineering	50%	28%	37%
Lighting design	0%	6%	3%
Interior Design	0%	0%	0%
Other	0%	0%	0%
Totals	100%	100%	100%
# Respondents	12	18	30

Q1.2 How would you describe your own position?

	East	West	All
Architect	8%	6%	7%
Contractor	0%	0%	0%
Engineer	58%	33%	43%
Designer	33%	28%	30%
Distributor	0%	6%	3%
Other	0%	28%	17%
Totals	100%	100%	100%
# Respondents	12	18	30

Q1.3 Roughly how many commercial and industrial projects did your firm work on in the last 12 months that involved design, layout, or specification of lighting equipment?

	East		West		All	
Large	35	n=2	109	n=10	102	n=12
Medium	80	n=5	29	n=3	61	n=8
Small	48	n=5	15	n=5	31	n=10

Q1.4 What services do you typically provide in your lighting design work? [UNAIDED] [MULTIPLES ACCEPTED]

	East	West	All
Fixture layout	100%	94%	96%
Equipment specification	82%	94%	89%
Computer modeling	45%	41%	43%
Design of lighting controls	64%	76%	71%
Controls commissioning guidelines	9%	12%	11%
Integrated daylighting design	27%	29%	29%
Construction oversite	36%	29%	32%
Commissioning	0%	0%	0%
# Respondents	11	17	28

Q1.5 How many full-time equivalent workers of all types do you employ at this location?

	East		West		All	
Large	30	n=2	73	n=10	66	n=12
Medium	12	n=5	13	n=3	13	n=8
Small	5	n=5	3	n=5	4	n=10

Q1.6 How old is your company?

	East		West		All	
Large	81	n=2	21	n=5	38	n=7
Medium	38	n=4	13	n=2	29	n=6
Small	14	n=5	22	n=4	17	n=9

Q1.7 Approximately, what were the total revenues for your company in 1999 at this location?

	East		West		All	
Large	$5,000,000	n=2	$9,900,000	n=10	$9,083,333	n=12
Medium	$1,250,000	n=4	$1,600,000	n=2	$1,337,500	n=6
Small	$437,500	n=2	$666,667	n=3	$575,000	n=5
Average	*$1,604,167*	*n=8*	*$5,900,000*	*n=15*	*$4,181,667*	*n=23*

Q1.8 Approximately, what share of your company's annual revenue is related to commercial and industrial lighting work?

	East	West	All
Large	5%	34%	31%
Medium	41%	12%	30%
Small	25%	37%	31%
Average	30%	31%	31%
# Respondents	11	17	28

Q1.9 Approximately, what percentage of all your commercial and industrial lighting work is made up by…

	East	West	All
New Construction	58%	73%	67%
Major Renovation and Remodeling	40%	22%	29%
Retrofit of Operable Equipment	3%	3%	3%
Replacement of Failed Equipment	0%	2%	1%
Total	100%	100%	100%
# Respondents	11	18	29

Q1.10 Again, in rough terms, what percentage of your commercial and industrial lighting work is done with…

	East	West	All
Offices	36%	30%	33%
Retail	21%	21%	21%
Other Commercial	26%	35%	31%
Industrial	17%	14%	15%
Totals	100%	100%	100%
# Respondents	11	17	28

Q1.11 Developers, owners, tenants, architects, electrical engineers, general contractors, and lighting designers are all important decision makers in building projects. For the work you do on new construction projects in the commercial and industrial sector, who has the most influence in making the following decisions?

Q1.11a Specification of lighting equipment

	East	West	All
Developer	8%	0%	3%
Owner	0%	11%	7%
Tenant	0%	0%	0%
Architect	8%	17%	13%
Electrical Engineer	58%	33%	43%
General Contractor	0%	0%	0%
Lighting Designer	25%	39%	33%
Other	0%	0%	0%
Totals	100%	100%	100%
# Respondents	12	18	30

Q1.11b Layout of lighting fixtures

	East	West	All
Developer	10%	5%	7%
Owner	0%	0%	0%
Tenant	0%	0%	0%
Architect	0%	25%	17%
Electrical Engineer	70%	40%	50%
General Contractor	0%	0%	0%
Lighting Designer	20%	30%	27%
Other	0%	0%	0%
Totals	100%	100%	100%
# Respondents	10	18	28

Q1.11c Decisions about what type of lighting controls to use

	East	West	All
Developer	0%	0%	0%
Owner	17%	14%	15%
Tenant	0%	0%	0%
Architect	8%	14%	12%
Electrical Engineer	67%	55%	59%
General Contractor	0%	0%	0%
Lighting Designer	8%	14%	12%
Other	0%	5%	3%
Totals	100%	100%	100%
# Respondents	11	18	29

Q1.12 For what percentage of your projects does your firm have primary responsibility for each of the following decisions:

	East	West	All
Building Orientation	11%	25%	20%
Size & Placement of Fenestration	12%	41%	30%
Specification of Lighting Fixtures	83%	70%	74%
Layout of Lighting Fixtures	79%	67%	71%
Specification of Lighting Controls	82%	56%	65%
# Respondents	9	16	25

Q3.1 What would you say were the most important design and equipment trends in the commercial and industrial lighting market over the past three years?

	East	West	All
Technical Trends	65%	65%	65%
Improving existing controls, lamps			
New technologies: T5s, Dimming ballasts, high-bay CFLs, new MH			
Niche innovations: MR-16s, pulse-start high intensity discharge lamps			
Practices	20%	19%	20%
Increase in efficiency practices: daylighting, "green" development, energy savings			
Increased design with: modular, design-build and assisted living projects			
A sociological change of pace (East)			
More Stringent Codes	5%	6%	6%
More restrictive codes, emphasis on code compliance			
General Comments	5%	7%	5%
Better product availability			
Increased energy costs			
Rebates have been eliminated			
Don't Know	0%	3%	2%
Nothing New	5%	0%	2%
Total	100%	100%	100%

Q3.2 And, what do you think will be the most important design and equipment trends in the commercial and industrial lighting market over the next three years?

	East	West	All
Technical Trends	38%	61%	52%
Improving existing controls, lamps, light quality, efficiency			
New technologies: T5s, Dimming ballasts, direct/indirect lighting, LED's as a light source, universal ballasts			
Niche innovations: fusion lamps, etc.			
Practices	31%	25%	27%
Better design practices, more daylighting with skylights			
Quick-built projects with modular lighting designs			
More fixture choices in efficient options			
Continued efficiency increases			
Cost	6%	0%	2%
Operational costs are rising			
Code	13%	4%	7%
Expect to see strengthening of code			
Don't Know	13%	11%	11%
Total	100%	100%	100%

Q4.1a First, what would you say are the most important factors in your decision making for determining commercial lighting equipment selection? [UNAIDED] [ACCEPT MULTIPLES]

	East	West	All
Initial cost of the equipment	28%	14%	20%
Total lifecycle costs \ energy efficiency	8%	3%	5%
Lighting level (appropriate illuminance)	12%	14%	13%
Lighting quality (color, visual comfort, etc.)	24%	34%	30%
Meeting code requirements	4%	9%	7%
Ease of lamp replacement, maintenance	12%	9%	10%
Flexability in initial cofiguring	0%	0%	0%
Ease of equipment reuse/relocatability	0%	0%	0%
Passing architects' review.	4%	6%	5%
Other (Specify)	8%	11%	10%
Totals	100%	100%	100%
# Respondents	11	18	29

Q4.1b Now I'd like you to rate the importance of the following factors in your decision making for determining commercial lighting *equipment selection*. I'd like you to rate these factors on a scale of 1 to 5 where 1 is not at all important and 5 is very important.

	East	West	All
Initial Cost of Equipment	4.0	3.6	3.8
Total Lifecycle Costs/Energy Efficiency	3.6	3.5	3.5
Quality of Light	3.9	4.8	4.4
Ease of Maintenance	2.9	3.5	3.2
# Respondents	10	12	22

Q4.2 How often, if at all, would you say you use each of the following tools in your commercial lighting design process? [Often=1, Sometimes=2, Rarely=3, Never=4]

	East	West	All
IES Reference Manuals	1.5	1.7	1.6
Manufacturer/In-house Layout Templates	2.9	3.2	3.0
Room Cavity Modeling	2.1	2.5	2.3
Ray-tracing Computer Modeling	3.1	3.2	3.2
Radiosity Computer Models	3.8	2.6	3.1
Other	1.0	1.3	1.2
# Respondents	12	16	28

Q4.3 And how often do you specify the following equipment in projects where you have control over equipment selection? [Often=1, Sometimes=2, Rarely=3, Never=4]

	East	West	All
34W ES T12 Lamped Fixtures	3.4	3.6	3.5
Linear T8 Lamped Fixtures	1.3	1.1	1.2
Linear T5 Lamped Fixtures	3.2	2.8	3.0
Magnetic Ballasts	3.3	3.6	3.5
Electronic Ballasts	1.2	1.1	1.1
Dimming Ballasts	2.6	2.8	2.7
Daylighting Controls	2.8	2.3	2.5
Occupancy Sensors	1.8	1.8	1.8
Lighting EMS	2.7	3.0	2.9
Indirect or I/D Pendant Fixtures	1.9	1.4	1.6
Hardwired CFL Fixtures	1.8	1.1	1.4
LED Exit Signs	1.2	1.1	1.1
Compact Metal Halide Fixtures	2.4	1.9	2.1
# Respondents	12	16	28

Q4.4 How frequently do you find that the lighting equipment actually installed differs from the original specification on your new construction projects? [Often=1, Sometimes=2, Rarely=3, Never=4]

	East	West	All
Rating	2.5	2.9	2.7
# Respondents	11	14	25

Q5.1 On a scale of 1 to 5 where 1 means you are completely unfamiliar and 5 means you are an expert, how would you rate your knowledge of the following areas relating to daylighting?

	East	West	All
Building Siting for Daylighting	2.2	2.2	2.2
Fenestration Design and Specification	2.3	2.4	2.4
Calculations and Analysis	2.3	2.2	2.3
Specification of electric lighting controls for integration with daylighting systems	2.7	2.6	2.6
# Respondents	11	14	25

Q5.2 What do you think are the benefits, if any, of using daylight versus electric light in commercial and industrial buildings? [UNAIDED] [ACCEPT MULTIPLES]

	East	West	All
Improved productivity/performance	14%	9%	11%
Increased Sales (Retail)	0%	7%	4%
Increased Occupant Satisfaction	18%	16%	16%
Reduced Energy Costs	43%	31%	36%
Increased Building Valuation	11%	13%	12%
Reduced Eye Strain	7%	2%	4%
No benefits	0%	2%	1%
Other (Specify)	7%	20%	15%
Totals	100%	100%	100%
# Respondents	12	17	29

Q5.3 What are all the reasons that might keep designers from choosing a daylighting design that reduces lighting energy use with dimming or other controls? [UNAIDED] [ACCEPT MULTIPLES]

	East	West	All
First Cost	35%	27%	30%
Equipment Reliability	6%	6%	6%
Potential for Maintenance Problems	12%	6%	8%
Customer's Lack of Awareness of Dimming Controls	0%	12%	8%
Customer's Lack of Information about Dimming Controls	6%	18%	14%
Other	41%	30%	34%
Totals	100%	100%	100%
# Respondents	6	13	19

Q5.4 What about occupancy sensors? What are the reasons that might keep designers from choosing occupancy sensors? [UNAIDED] [ACCEPT MULTIPLES]

	East	West	All
First Cost	26%	33%	30%
Equipment Reliability	26%	11%	17%
Maintenance Problems	11%	15%	13%
Customer's Override/Misuse	5%	4%	4%
Commissioning/Re-tuning Costs	11%	19%	15%
Inappropriate for space type	11%	7%	9%
Other	11%	11%	11%
Totals	100%	100%	100%
# Respondents	9	14	23

Q5.5a Turning back to daylighting, do you ever work with architects, developers, or owners early in the design phase of a project to influence the degree to which daylighting features are included in the building shell?

	East	West	All
Often	0%	13%	8%
Sometimes	10%	33%	24%
Rarely	30%	20%	24%
Never	60%	33%	44%
Totals	100%	100%	100%
# Respondents	10	15	25

Q5.5b On roughly what percentage of your lighting projects, if any, have you provided daylighting controls and/or dimming ballasts over the past two years?

	East	West	All
Percent	14%	22%	18%
# Respondents	11	15	26

Q5.6 And, more generally, do you actively pursue daylighting as part of your design practice?

	East	West	All
Yes, currently	18%	35%	29%
Not currently, plan to in future	45%	24%	32%
No	36%	41%	39%
Totals	100%	100%	100%
# Respondents	11	17	28

Q5.7 What percentage of your clients, if any, have asked you to design daylit buildings over the past two years?

	East	West	All
Percent	1.1%	3.6%	2.6%
# Respondents	11	15	26

Q5.8 Do you think daylighting could play a more significant role in lighting C&I buildings?

	East	West	All
Yes	82%	76%	79%
No	9%	12%	11%
Don't Know	9%	12%	11%
Totals	100%	100%	100%
# Respondents	11	17	28

Q5.9 What do you think are the biggest hurdles to keeping daylighting from being used more? [UNAIDED] [MULTIPLES ACCEPTED]

	East	West	All
Fragmentation of specialties	26%	29%	28%
Climate too cloudy	5%	0%	2%
Extra equipment cost	16%	29%	23%
Extra labor cost	11%	25%	19%
Glare problems	5%	0%	2%
Thermal compromise (overheating or cooling)	5%	0%	2%
Need for follow-up maintenance and re-tuning	5%	4%	5%
Other (Specify)	26%	13%	19%
Totals	100%	100%	100%
# Respondents	11	14	25

Q5.10 What improvements or changes do you think need to be made to increase the use of daylighting?

	East	West	All
Advertising	21%	11%	15%
Increase awareness: greater exposure in publications, target advertising			
Expose the benefits of daylighting (productivity, valuation,etc)			
Cost	0%	11%	7%
Paybacks - different for gov't and private			
Cost of controllers and dimming ballasts must come down			
Design Tools Needed	14%	7%	10%
Simple design tools (linked to CAD)			
Controls are too complex - need simpler controls			
Code	7%	0%	2%
State codes need to mandate daylighting			
Education	57%	70%	66%
Educate/train architects, designers, developers, engineers			
Allow time for design			
Total	100%	100%	100%

Q5.11 How interested, if at all, would you say your firm is in doing (more) design work with daylighting? *[including fenestration, siting, massing, dimming controls, etc.]*

	East	West	All
Very Interested	33%	54%	45%
Somewhat Interested	56%	38%	45%
Not Interested	11%	8%	9%
Don't Know	0%	0%	0%
Totals	100%	100%	100%
# Respondents	9	13	22

Q6.1 Which, if any, new or emerging lighting technologies or practices do you think are most promising?

	East	West	All
Technologies	83%	86%	85%
Improving existing controls, lamps, ballasts, light quality, efficiency, occupancy sensors			
New technologies: T5s, LEDs, induction lamps, fusion lamps, low voltage lighting			
Niche innovations: fiber optics, mini MR-16			
Practices	8%	11%	10%
Daylighting and controls for new construction			
Availability	4%	0%	2%
Quicker product delivery with “just-in-time”			0
Cost	4%	0%	2%
Reduced lamp costs for T5s, CFLs			
Don't Know	0%	4%	2%
Total	100%	100%	100%

Q6.2 In terms of maintaining your firm's competitive position, how important would you say it is that you offer energy efficient lighting technologies and design options to your clients? Would you say,

	East	West	All
Very important	38%	79%	64%
Somewhat important	38%	14%	23%
Not very important	25%	7%	14%
Not at all important	0%	0%	0%
Totals	100%	100%	100%
# Respondents	8	14	22

Q6.3 What sources do you typically use to keep abreast of new lighting technologies and design practices? [UNAIDED]

	East	West	All
Other lighting designers	10%	13%	12%
Distributors	10%	13%	12%
Manufacturers	50%	75%	65%
Trade magazines	40%	50%	46%
Websites	20%	25%	23%
Trade shows (e.g., Lightfair)	10%	38%	27%
Northwest Lighting Lab	10%	6%	8%
PGE Lighting Lab	0%	0%	0%
Other: (Specify)	20%	31%	27%
# Respondents	10	16	26

Q6.4a Are you aware of the Lighting Design Lab in Seattle?

	East	West	All
Yes	80%	81%	81%
No	20%	19%	19%
# Respondents	10	16	26

Q6.4b [If YES] Have you ever been to the Design Lab?

	East	West	All
Yes	50%	36%	42%
No	50%	64%	58%
# Respondents	10	14	24

Q6.4c Have you ever used any of the services offered by the Design Lab?

	East	West	All
Yes	44%	63%	53%
No	56%	38%	47%
# Respondents	9	8	17

Q6.4d [If YES] Which services have you used? [ACCEPT MULTIPLES]

	East	West	All
Consultations	11%	13%	12%
Mock-up facilities	0%	25%	12%
Classes	33%	25%	29%
Tours	22%	0%	12%
Daylighting Simulations	11%	13%	12%
Attended LDL Roadshow (LDL came to company/area)	0%	25%	12%
Other (Specify)	22%	0%	12%
Totals	100%	100%	100%
# Respondents	4	5	9

Q6.5a Are you aware of the PGE Lighting Lab in Portland?

	East	West	All
Yes	30%	69%	54%
No	70%	31%	46%
# Respondents	10	16	26

Q6.5b [If YES] Have you ever you ever used any of the services offered by the PGE Lighting Lab?

	East	West	All
Yes	0%	33%	22%
No	100%	67%	78%
# Respondents	6	12	18

Q6.6a Have you ever used the website www.lightsearch.com?

	East	West	All
Yes	33%	33%	33%
No	67%	67%	67%
# Respondents	9	15	24

Q6.6b [If YES] Have you ever you ever used any of the services offered by the www.lightsearch.com?

	East	West	All
Yes	40%	67%	55%
No	60%	33%	45%
# Respondents	5	6	11

C

SURVEY INSTRUMENTS

In this appendix we provide the three survey instruments used for the primary data collection in this study. First we present the survey for the lighting designers, followed by distributors and contractors.

C.1 LIGHTING DESIGNER SURVEY

LIGHTING DESIGNER SURVEY QUESTIONS

Notes:

1. Survey to be administered by Energy Professional
2. Target 30 completes by July 1, 2000

C.1.1 Intro

Hi my name is _____________. I'm with XENERGY, an energy research firm. We are conducting research on the commercial and industrial lighting market in new construction and major renovations in your area. [IF WE HAVE A REFERENCE WHOSE NAME WE CAN USE: We were referred to your company by _________.] The interview will take about 20 minutes. All information you provide will be kept confidential and will not be associated in any way with you or your company.

May we please speak to the person most familiar with your firm's lighting design and specification work?

C.1.2 Screening

SC1. Does your company…[ACCEPT MULTIPLES]

- Manufacture commercial or industrial lighting equipment 1
- Design or layout commercial or industrial lighting 2
- Install commercial or industrial lighting equipment................ 3
- Sell commercial or industrial lighting equipment................... 4

SC2. Is commercial and industrial lighting a significant part of your business?

- Yes.. 1
- No... 2
- Don't Know 9

IF SC2 = NO, THEN ASK

SC3. Do you design the lighting system or specify the lighting equipment on a third or more of your projects?

- Yes.. 1
- No... 2
- Don't Know 9

IF [SC1 = 1 AND SC2 = 1] OR [SC2 = 2 AND SC3 = 1] THEN PROCEED. OTHERWISE THANK AND END SURVEY.

C.1.3 Classification / Firmographics

1.1 Of the following, which best describes your firm's business?

- Architectural....................1
- Electrical contracting....................2
- Lighting contracting....................3
- Lighting wholesale/distributing....................4
- Electrical engineering....................5
- Consulting engineering....................6
- Lighting design....................7
- Interior design....................8
- Other (______________________________)...............9

1.2 How would you describe your own position?

- Architect....................1
- Contractor....................2
- Engineer....................3
- Designer....................4
- Distributor....................5
- Other (______________________________)...............6

1.3 Roughly how many commercial and industrial projects did your firm work on in the last 12 months that involved design, layout, or specification of lighting equipment?

ENTER NUMBER.._____

1.4 What services do you typically provide in your lighting design work? [UNAIDED]

- Fixture layout....................1
- Equipment specification....................2
- Computer modeling....................3
  - (Programs used:_________________________)
- Design of lighting controls....................4
- Controls commissioning guidelines....................5
- Integrated daylighting design....................6
- Construction oversite....................7
- Commissioning....................8

1.5 How many full-time equivalent workers of all types do you employ at this location?

ENTER NUMBER OF FTEs..................................._____

1.6 How old is your company?

ENTER YEARS ...._____

1.7 Approximately, what were the total revenues for your company in 1999 at this location?

ENTER $DOLLARS..$_____

1.8 Approximately, what share of your company's annual revenue is related to commercial and industrial lighting work?

ENTER PERCENTAGE .... _____%

1.9 Approximately, what percentage of all your commercial and industrial lighting work is made up by…

New construction.. _____%
Major renovation and remodeling .... _____%
Retrofit of operable equipment.............................. _____%
Replacement of failed equipment .... _____%
100%

1.10 Again, in rough terms, what percentage of your commercial and industrial lighting work is done with…

Office .... _____%
Retail .... _____%
Other commercial.. _____%
Industrial... _____%
100%

1.11 Developers, owners, tenants, architects, electrical engineers, general contractors, and lighting designers are all important decision makers in building projects. For the work you do on new construction projects in the commercial and industrial sector, who has the most influence in making the following decisions?

	Developer	Owner	Tenant	Architect	Electrical Engineer	General Contractor	Lighting Designer	Other	Specify "Other"
Specification of lighting fixtures									
Layout of lighting fixtures									
Decision about what type of lighting controls to use									

1.12 For what percentage of your projects does <u>your firm</u> have primary responsibility for each of the following decisions:

	% of Projects	DK
Building orientation..	_____%	___
Size and placement of windows and skylights..........	_____%	___
Specification of lighting fixtures.............................	_____%	___
Layout of lighting fixtures	_____%	___
Specification of lighting controls	_____%	___

C.1.4 Regional Product Purchases

2.1 Which firms would you say are the one or two biggest suppliers of commercial lighting equipment in your local area? *[Get name and city]*

C.1.5 General Market Trends

Now, a couple of questions on general market trends.

3.1 What would you say were the most important design and equipment trends in the commercial and industrial lighting market over the past three years?

3.2 And, what do you think will be the most important design and equipment trends in the commercial and industrial lighting market over the next three years?

C.1.6 Design / Specification Practices

4.0a Now I'd like you to describe your firm's general approach to a typical new construction commercial lighting design job? What tend to be the key design issues you emphasize and **what types of tools or guides** do you use, if any?

4.0b More specifically, how do you determine the appropriate illuminance levels and lighting power densities in your designs? *[VERBATIM. NOTE ALL SPECIFIC REFERENCES TO CODE LIMITS AND SPACE USAGE TYPE]*

4.0c When designing a fixture layout, how do you determining where the fixtures should be located? [NOTE ANY REFERENCES TO TEMPLATES]

Now I'd like to talk to you about your firm's lighting design and specification practices.

4.1a First, what would you say are the most important factors in your decision making for determining commercial lighting equipment selection? [UNAIDED, DO NOT READ. ACCEPT MULT.]

Initial cost of the equipment...1
Total lifecycle costs \ energy efficiency.............................2
Lighting level (appropriate illuminance)..............................3
Lighting quality (color, visual comfort, etc.).........................4
Meeting code requirements...5
Ease of lamp replacement, maintenance.............................6
Flexibility in initial configuring 7
Ease of equipment reuse/relocatability...............................8
Other, Specify___________ 9

4.1b Now I'd like you to rate the importance of the following factors in your decision making for determining commercial lighting *equipment selection*. I'd like you to rate these factors on a scale of 1 to 5 where 1 is not at all important and 5 is very important.

Initial cost of the equipment....................................._____
Total lifecycle costs \ energy efficiency....................._____
Quality of Light..._____
Ease of Maintenance ...._____

4.1c In what ways, if any, would you say these factors differ in relative importance in the industrial sector?

4.2 How often, if at all, would you say you use each of the following tools in your commercial lighting design process? [Often=1, Sometimes=2, Rarely=3, Never=4]

IES reference manuals...___
Manufacturer/in-house layout templates ....___
Room cavity modeling...___
Ray-tracing computer models (e.g., Radiance, Lightscape)...............___
Radiosity computer models (e.g., Lumen-micro, Genesys) ....___
Other: __________________________________ ....___

4.3 And how often do you specify the following equipment in projects where you have control over equipment selection?

	Often	Sometimes	Rarely	Never
1. 34 W Energy Saver T12 lamped fixtures				
2. Linear T8 lamped fixtures				
3. Linear T5 fixtures				
4. Magnetic ballasts				
5. Electronic ballasts				
6. Dimming ballasts				
7. Daylighting controls				
8. Occupancy sensors				
9. Lighting EMS				
10. Indirect or I/D pendant fixtures				
11. Hardwired CFL fixturs				
12. LED exit signs				
13. Compact Metal Halide fixtures				

AS APPROPRIATE FROM RESPONSES TO PREVIOUS QUESTION…

4.3a *[If NEVER or RARELY use T8 lamps]* Why don't you use T8 lamps more often in your designs?

4.3b *[If NEVER or RARELY use electronic ballasts]* Why don't you use electronic ballasts more often in your designs?

4.3c *[If NEVER or RARELY use occupancy sensors]* Why don't you use occupancy sensors more often in your designs?

4.3d *[If NEVER or RARELY use compact fluorescents]* Why don't you use compact fluorescents more often in your designs?

4.4 How frequently do you find that the lighting equipment actually installed differs from the original specification on your new construction projects?

Often..1
Sometimes..2
Rarely...3
Never 4
Don't Know 9

IF 1 OR 2, THEN ASK

4.5 And why is that?

C.1.7 Controls and Daylighting Practices

5.0 Now I'd like to talk with you about daylighting. Are you familiar with the process of designing buildings to use daylight in such a way that electrical energy consumption for lighting is reduced? [IF NO, then provide brief explanation]

Yes..1
No...2

5.1 On a scale of 1 to 5 where 1 means you are completely unfamiliar and 5 means you are an expert, how would you rate your knowledge of the following areas relating to daylighting?

Building siting for daylighting....................................._____
Fenestration design and specification for daylighting ...._____
Daylighting calculations and analysis ...._____
Specification of electric lighting controls
for integration with daylighting systems......................_____

5.2 What do you think are the benefits, if any, of using daylight versus electric light in commercial and industrial buildings? [Unaided, do not read. Record all mentioned.]

Improved productivity/performance..................................1
Increased sales (Retail)..2
Increased occupant satisfaction 3
Reduced energy costs 4
Increased building valuation 5
Reduced eye strain 6
Other (Specify___________________________) 7

5.3 What are all the reasons that might keep designers from choosing a daylighting design that reduces lighting energy use with dimming or other controls? [UNAIDED]

	Mentioned	Emphasized
First cost		
Equipment reliability		
Potential for maintenance problems		
Customer's lack of awareness of dimming controls		
Customers' lack of information about dimming controls		
Other:		

5.4 What about occupancy sensors? What are the reasons that might keep designers from choosing occupancy sensors? [UNAIDED]

	Mentioned	Emphasized
First cost (including setup and tuning)		
Equipment reliability		
Potential for maintenance problems		
Customer's override/misuse of occupancy controls		
Commissioning/re-tuning costs		
Other:		

5.5a Turning back to daylighting, do you ever work with architects, developers, or owners early in the design phase of a project to influence the degree to which daylighting features are included in the building shell?

Often..1
Sometimes...2
Rarely...3
Never 4
Don't know / No answer.....................................9

5.5b On roughly what percentage of your lighting projects, if any, have you provided daylighting controls and/or dimming ballasts over the past two years?

ENTER % .... _____%

IF 5.5b > 0% ASK 5.5c ELSE SKIP TO 5.6

5.5c And in those cases in which you specified daylighting controls and/or dimming ballasts in the past two years, how satisfied were you and your clients with the performance of the systems? PROBE ON ANY PROBLEMS

5.6 And, more generally, do you actively pursue daylighting as part of your design practice?

Yes, currently..1
Not currently, but plan to in the future 2
No...3
Don't Know 9

If NO, why not?

5.7 What percentage of your clients, if any, have asked you to design daylit buildings over the past two years?

ENTER PERCENTAGE .... _____%

5.8 Do you think daylighting could play a more significant role in lighting C&I buildings?
- Yes..1
- No...2
- Don't Know..9

5.8a [If YES] Where and how could daylighting displace electric lighting energy use?
[If NO] Why not?

5.9 What do you think are the biggest hurdles to keeping daylighting from being used more? [DO NOT PROMPT]
- Fragmentation of specialties...1
- Climate too cloudy...2
- Extra equipment cost...3
- Extra labor cost...4
- Glare problems..5
- Thermal compromise (overheating or cooling)....................6
- Need for follow-up maintenance and re-tuning...................7
- Other (Specify)______________________....................8

5.10 What improvements or changes do you think need to be made to increase the use of daylighting? *[in design, installation, commissioning, equipment cost/quality, etc.]*

5.11 How interested, if at all, would you say your firm is in doing (more) design work with daylighting? *[including fenestration, siting, massing, dimming controls, etc.]*
- Very interested...1
- Somewhat interested...2
- Not interested...3
- Don't know / No answer..9

5.11a Why/why not?

C.1.8 Suggestions

6.1 Which, if any, new or emerging lighting technologies or practices do you think are most promising? (Clarify, not restricted to those mentioned in this survey.)

6.2 In terms of maintaining your firm's competitive position, how important would you say it is that you offer energy efficient lighting technologies and design options to your clients? Would you say,

Very important 1
Somewhat important 2
Not very important... 3
Not at all important 4

6.3 What sources do you typically use to keep abreast of new lighting technologies and design practices? *[Unaided]*

Other lighting designers 1
Distributors.. 2
Manufacturers.. 3
Trade magazines.. 4
List:_______________
Websites 5
List:_______________
Trade shows (e.g. Lightfair)...................................... 6
List:_______________
Northwest Lighting Lab.. 7
PGE Lighting Lab... 8
Other: _____________________________________ 9
Don't Know 10

6.4a Are you aware of the Lighting Design Lab in Seattle?

Yes.. 1
No.. 2

6.4b [If YES] Have you ever been to the Design Lab?

Yes.. 1
No.. 2

[If NO] Why not?

6.4c Have you ever used any of the services offered by the Design Lab?

Yes.. 1
No.. 2

6.4d [If YES] Which services have you used?

Consultations 1
Mock-up facilities 2
Classes 3
Tours... 4
Daylighting simulations 5
Other, Specify______________ 6

6.5a Are you aware of the PGE Lighting Lab in Portland?

Yes.. 1

No..2

6.5b [If YES] Have you ever you ever used any of the services offered by the PGE Lighting Lab?
Yes...1
No..2

[IF Yes] Which services?

6.6a Have you ever used the website www.lightsearch.com?
Yes...1
No..2

6.6b [If YES] Have you ever you ever used any of the services offered by the www.lightsearch.com?
Yes...1
No..2

[IF Yes] Which services?

6.7 Finally, do you have any ideas for initiatives in energy efficient commercial lighting that could be pursued by the Northwest Energy Efficiency Alliance?

Close: This research is sponsored by the Northwest Energy Efficiency Alliance. The Northwest Energy Efficiency Alliance very much appreciates your participation in this research and values your insights.

The Alliance is considering new initiatives in commercial and industrial lighting and may be seeking firms and individuals to participate in an lighting advisory group in the future. Is this something in which you or your firm would be interested in participating?
Yes...1
No..2
Name: ____

THANK FOR PARTICIPATION

C.2 LIGHTING DISTRIBUTOR SURVEY

LIGHTING DISTRIBUTOR SURVEY QUESTIONS

Notes:

1. Survey to be administered by phone house or energy professional
2. Target 60 completes by July 1, 2000

C.2.1 Intro

Hi my name is _____________. I'm with XENERGY, an energy research firm. We are conducting research on the commercial and industrial lighting market in new construction and major renovations in your area. [IF WE HAVE A REFERENCE WHOSE NAME WE CAN USE: We were referred to your company by _________.] The interview will take about 20 minutes. All information you provide will be kept confidential and will not be associated in any way with you or your company.

May we please speak to the manager or person at your firm most familiar with commercial and industrial lighting products?

C.2.2 Screening

SC1. Does your company…[ACCEPT MULTIPLES]

Manufacture commercial or industrial lighting equipment 1
Design or layout commercial or industrial lighting 2
Install commercial or industrial lighting equipment................ 3
Sell commercial or industrial lighting equipment................... 4

IF SC1=4 ASK SC2, ELSE TERMINATE

SC2 Are you a retailer distributor selling to the general public or a wholesaler who sells to contractors and installers?

Retail Distributor.. 1
Wholesale Distributor.. 2
Both.. 3

IF SC2 = 2 OR 3, THEN ASK SC3, ELSE TERMINATE

SC3. Does your firm sell more than $50,000 of business in commercial and industrial lighting equipment a year?

Yes... 1
No.. 2
Don't Know 9

IF SC3 = 1 THEN PROCEED. OTHERWISE THANK AND END SURVEY.

C.2.3 Classification / Firmographics

1.1 Of the following, which best describes your firm's business?

Catalog / mail order firm...1
General industrial supplier...2
RECORD NAMES OF MFRs___________________
Electrical equipment supplier..3
Lighting supplier only...4
Manufacturer representative..5
RECORD NAME OF MFR_____________________

1.2 How would you describe your own position?

General sales...1
Electrical sales...2
Lighting sales...3
Manager 4
Other (________________________________)...............5

1.3a Does your company provide lighting design and specification services other than equipment sales such as…

Lighting design and fixture layout.......................................1
Equipment specification...2
Neither..3

IF 1.3a = 3, SKIP to 1.4

1.3b And could you please describe the various types of lighting services you provide? (PROBE: Number and type of staff involved, individual or department, etc.)

1.3c Roughly how many commercial and industrial projects did your firm work on in the last 12 months that involved design, layout, or specification of lighting equipment?

ENTER NUMBER..._____

1.4 How many full-time equivalent workers of all types do you employ at this location?

ENTER NUMBER OF FTEs..................................._____

1.5 How old is your company?

ENTER YEARS ...._____

1.6 Approximately, what were the total revenues for your company in 1999 at this location?

ENTER $DOLLARS..$_____

[**If reluctant or refuses, ask which range they would fall in.]**

< $1 million..1
$1 - 4.9 million...2
$5 - 9.9 million...3
$10 -49.9 million...4
>$50 million..5
Don't know/Proprietary 6

1.7 Approximately, what share of your company's annual revenue at this location is related to commercial and industrial lighting?

ENTER PERCENTAGE .... _____%

1.8 What percent of your commercial lighting equipment sales are to each of the following…

Contractors\builders..______%
Direct to end users ....______%
Other distributors..______%
Retail Stores ....______%
Other: ________________________________.....______%
100 %

C.2.4 Equipment Sales

Next I'd like to talk to you about your firm's sales of commercial and industrial lighting equipment.

2.1 I'd like to read you a list of a several lighting technologies and I'd like you tell me whether or not you stock each one, and whether your sales volume has increased, decreased, or stayed about the same over the last 3 years. *[check all that apply]*

	Sell Less	Sell Same	Sell More	Don't Stock
T-8 lamps	( )	( )	( )	( )
T-5 lamps	( )	( )	( )	( )
Electronic ballasts	( )	( )	( )	( )
Dimming electronic ballasts	( )	( )	( )	( )
Daylighting controls (Photocells, controllers, interfaces,etc.)	( )	( )	( )	( )
Occupancy sensors	( )	( )	( )	( )
Linear fluorescent pendant fixtures	( )	( )	( )	( )
Hardwired compact fluorescent fixtures (CFLs)	( )	( )	( )	( )
LED exit signs	( )	( )	( )	( )
Compact Metal Halide lamps	( )	( )	( )	( )

2.2 What year did you begin carrying the following product types? *[READ LIST]*

ENTER YEAR. **Year**

T-5 lamps (new generation)..a.______
Electronic ballasts...b.______
Dimming electronic ballasts ....c.______
Compact fluorescent lamps...d.______
Daylighting sensors and controls ....e.______
Compact Metal Halide (39 - 100 W) ....f. ______

Now we would like to ask some questions about your company's sales of efficient lighting equipment

2.3 Of all your downlight or sconce sales, what percent were compact fluorescent in 1999? And how about in 1996? (NOTE: CURRENT HIGHER PRIORITY THAN '96)

ENTER PERCENT... 1999 _____%
ENTER PERCENT... 1996 _____%

2.4 Of all your linear fluorescent sales, what percent were T12, T8, and T5 in 1999? And how about in 1996? (NOTE: CURRENT HIGHER PRIORITY THAN '96)

	1999	1996
1. T-12 Linear Fluorescent Lamps..............................	_____%	_____%
2. T-8 Linear Fluorescent Lamps................................	_____%	_____%
3. T-5 Linear Fluorescent Lamps................................	_____%	_____%
4. Other (Specify: _______________________)_____%	_____%	
Total	100%	100%

2.5 Of all your linear fluorescent ballast sales, what percent were electronic in 1999? And how about in 1996?

	1999	1996
1. Magnetic Ballasts..	_____%	_____%
2. Electronic Ballasts...	_____%	_____%
3. Dimming Ballasts..	_____%	_____%
4. Other (Specify: _______________________)_____%	_____%	
Total	100%	100%

A Group

2.6 In what percentage of your commercial lighting supply projects do you need to submit competitive bids?

ENTER PERCENTAGE .... ______%

2.7 For the lighting equipment you sell into the commercial and industrial sector, who has the most influence in making the following decisions? [CHECK APPLICABLE BOXES]

	Developer	Owner/Tenant	Architect	Electrical Engineer	Lighting Designer	General Contractor	Ltg/Elec. Contractor	Ltg/Elec. Distributor	Other	Specify "Other"
Specification of lighting fixtures										
Layout of lighting fixtures										
Decision to use lighting controls										

C.2.5 General Market Trends

Now, a couple of questions on general market trends.

3.1 What would you say were the most important trends in the commercial and industrial lighting market over the past three years?

3.2 And, what do you think will be the most important trends in the commercial and industrial lighting market over the next three years?

3.3 In your opinion, what are the most important factors in running a profitable lighting equipment distributorship in today's market? [LISTEN FOR ANYTHING RELATED TO EFFICIENT EQUIPMENT OR DESIGN ASSISTANCE]

3.4 What would you say are the most important factors that determine which commercial lighting equipment you recommend to your customers? [Unaided, do not read. Record all mentioned.]

Initial cost of the equipment....................................1
Total lifecycle costs \ energy efficiency....................2
Lighting level (appropriate brightness) 3
Lighting quality (color, effect on look of merchandise).........4
Meeting code requirements.......................................5
Ease of lamp replacement, maintenance 6
Flexibility in initial configuring 7
Ease of equipment reuse/relocatability.......................8
Other, Specify____________ 9

PROBE AS NEEDED, ESP. DIFFERENCES BY SEGMENT, RECORD VERBATIM

3.5 When you attempt to sell or specify energy efficient lighting equipment, do you discuss any of the following characteristics?

Comparative operating costs (versus those of alternative equipment).... 1
Comparative lamp life and maintenance... 2
Comparative lumen depreciation 3
Effect of quality lighting on productivity or safety 4
Lifecycle costs/payback.. 5

3.6 How frequently do you find that the lighting equipment actually installed differs from the original specification on your new construction projects?

Always 1
Frequently 2
Sometimes...3
Rarely 4
Never 5
Don't Know 9

IF 1 OR 2, THEN ASK

3.6a And why is that?

B Group

C.2.6 Specification and Design Practices

4.0 In what percentage of commercial lighting projects do you have discretion over the kind of equipment specified?

ENTER PERCENTAGE .... ______%

IF 4.0 IS LESS THAN 20% THEN SKIP TO 4.2

Now I'd like to talk with you about some specific lighting technologies and practices. Thinking about those cases in which you perform the lighting design or specification function,

4.1 How often do you specify the following equipment in these projects?

	Often	Sometimes	Rarely	Never
1. 34 W Energy Saver T12 lamped fixtures				
2. Linear T8 lamped fixtures				
3. Linear T5 fixtures				
4. Magnetic ballasts				
5. Electronic ballasts				
6. Dimming ballasts and daylighting controls				
8. Occupancy sensors or Lighting EMS				
9. Indirect or I/D pendant fixtures				
10. Hardwired CFL fixtures				
11. LED exit signs				
12. Compact Metal Halide fixtures				

4.2 What are the reasons that might keep designers from using occupancy sensors in a design? [UNAIDED]

	Mentioned	Emphasized
First cost (including setup and tuning)		
Equipment reliability		
Potential for maintenance problems		
Customer's override/misuse of occupancy controls		
Commissioning/re-tuning costs		
Other:		

Are you familiar with the process of designing buildings to use daylight in such a way that electrical energy use for lighting is reduced? [IF NO, then brief explanation of daylighting]

4.3 In your opinion, what are the benefits, if any, of using daylighting in commercial and industrial buildings? [Unaided, do not read. Record all mentioned.]

Improved productivity/performance....................................1
Increased sales (Retail)..2
Increased occupant satisfaction 3
Reduced energy costs..4
Increased building valuation..5
Reduced eye strain 6
Other (Specify__________________________) 7

4.4 What are all the reasons that might keep designers from choosing a daylighting design that reduces lighting energy use with dimming or other controls? [UNAIDED]

	Mentioned	Emphasized
First cost		
Equipment reliability		
Potential for maintenance problems		
Customer's lack of awareness of dimming controls		
Customers' lack of information about dimming controls		
Other:		

4.5 On roughly what percentage of your lighting projects, if any, have you provided daylighting controls and/or dimming ballasts over the past two years?

ENTER % ...._____

IF 4.5 > 0% ASK 4.6 ELSE SKIP TO 4.7

4.6 And in those cases in which you provided daylighting controls and/or dimming ballasts in the past two years, how satisfied were you and your clients with the performance of the systems? [PROBE ON ANY PROBLEMS]

4.7 On roughly what percentage of your lighting projects, if any, have you provided occupancy controls or lighting EMS in the past two years?

ENTER % ...._____

C.2.7 Suggestions

5.1 Which, if any, new or emerging lighting technologies or practices do you think are most promising? (Clarify, not restricted to those mentioned in this survey.)

5.2 In what ways, if any, do you think these new lighting technologies or practices could be stimulated, promoted, or otherwise encouraged?

5.3 In terms of maintaining your firm's competitive position, how important would you say it is that you offer energy efficient lighting technologies or design options to your clients? Would you say,

Very important 1
Somewhat important 2
Not very important.. 3
Not at all important 4

5.4 What sources do you typically use to keep abreast of new lighting technologies and design practices? *[Unaided]*

Other lighting designers 1
Distributors.. 2
Manufacturers... 3
Trade magazines... 4
List:_______________
Websites 5
List:_______________
Trade shows (e.g. Lightfair) 6
List:_______________
Northwest Lighting Lab... 7
PGE Lighting Lab.. 8
Other: ____________________________________ 9
Don't Know 10

5.5a Are you aware of the Lighting Design Lab in Seattle?

Yes... 1
No.. 2

5.5b [If YES] Have you ever been to the Design Lab?

Yes... 1
No.. 2

[If NO] Why not?

5.5c Have you ever used any of the services offered by the Design Lab?
- Yes..1
- No..2

5.5d [If YES] Which services have you used?
- Consultations 1
- Mock-up facilities 2
- Classes 3
- Tours..4
- Daylighting simulations 5
- Other, Specify_______________ 6

5.6a Are you aware of the PGE Lighting Lab in Portland?
- Yes..1
- No..2

5.6b [If YES] Have you ever you ever used any of the services offered by the PGE Lighting Lab?
- Yes..1
- No..2

[IF Yes] Which services?

5.7a Have you ever used the website www.lightsearch.com?
- Yes..1
- No..2

5.7b [If YES] Have you ever used any of the services offered by the www.lightsearch.com?
- Yes..1
- No..2

[IF Yes] Which services?

This research is sponsored by the Northwest Energy Efficiency Alliance. The Northwest Energy Efficiency Alliance very much appreciates your participation in this research and values your insights. The Alliance is considering new initiatives in commercial and industrial lighting and may be seeking firms and individuals to participate in an lighting advisory group in the future.

5.8 Is this something in which you or your firm would be interested in participating?
- Yes..1
- No..2

IF YES, THEN: Name:________________________________

Phone:______________________

IF APPROPRIATE: For related research we are conducting, could you tell us which firms are the one or two biggest commercial/industrial contractors of lighting equipment in your local area? *[Get name and city]*

THANK FOR PARTICIPATION

C.3 LIGHTING INSTALLER SURVEY

LIGHTING CONTRACTOR SURVEY QUESTIONS

Notes:
1. Survey to be administered by Energy Professional
2. Target 30 completes

C.3.1 Introduction

Hi my name is _____________. I'm with XENERGY, an energy research firm. We are conducting research on the commercial and industrial lighting market in new construction and major renovations in your area. [IF WE HAVE A REFERENCE WHOSE NAME WE CAN USE: We were referred to your company by _________.] The interview will take about 15 minutes. All information you provide will be kept confidential and will not be associated in any way with you or your company.

May we please speak to the person most familiar with your firm's lighting contracting work?

C.3.2 Screening

SC1. Does your company…[ACCEPT MULTIPLES]
- Manufacture commercial or industrial lighting equipment 1
- Design or layout commercial or industrial lighting 2
- Install commercial or industrial lighting equipment................ 3
- Sell commercial or industrial lighting equipment................... 4

IF SC1 = 3 THEN CONTINUE, OTHERWISE THANK AND END SURVEY

SC2. Is commercial and industrial lighting a significant part of your business?
- Yes.. 1
- No... 2
- Don't Know 9

IF No or DK, THEN ASK

SC3. Does your company do more than $50,000 per year in commercial and industrial lighting work?
- Yes.. 1
- No... 2
- Don't Know 9

IF Yes, THEN PROCEED. OTHERWISE THANK AND END SURVEY.

C.3.3 Classification / Firmographics

1.1 Which of the following best describes your firm?

Electrical contractor..1
Lighting contractor..2
Lighting maintenance company 3
Other: ____ .4

1.2 How would you describe your own position?

Contractor..1
Engineer...2
Designer...3
Other (________________________________)...............4

1.3 Roughly how many commercial and industrial projects did your firm work on in the last 12 months that involved installation or retrofit of lighting equipment?

ENTER NUMBER.._____

1.4 How many full-time equivalent workers of all types do you employ at this location?

ENTER NUMBER OF FTEs..................................._____

1.5 How old is your company?

ENTER YEARS ...._____

1.6 Approximately, what were the total revenues for your company in 1999 at this location?

ENTER $DOLLARS..$_____

1.7 Approximately, what share of your company's annual revenue is related to commercial and industrial lighting work?

ENTER PERCENTAGE .... _____%

1.8 Approximately, what percentage of all your commercial and industrial lighting work is made up by…

New construction.. _____%
Major renovation and remodeling .... _____%
Retrofit of operable equipment.............................. _____%
Replacement of failed equipment .... _____%
100 %

1.9 In rough terms, what percentage of your commercial and industrial lighting work is done with…

Office .... _____%
Retail .... _____%
Other commercial... _____%
Industrial... _____%
100 %

C.3.4 General Market Trends

Now, a couple of questions on general market trends.

2.1 What would you say were the most important trends in the commercial and industrial lighting market over the past three years?

2.2 And, what do you think will be the most important trends in the commercial and industrial lighting market over the next three years?

C.3.5 Purchasing & Financing

3.1 What percentage of your commercial and industrial lighting equipment do you purchase from each of the following?

Traditional distributors.. _____%
Manufacturer's representatives .... _____%
Direct from manufacturer.................................... _____%
Home Depot or similar store................................. _____%
Other: _______________________________ ..... _____%
100 %

3.2 Do you ever buy lighting equipment through the internet?

Yes...1
No..2
Don't Know 9

3.3 Do you ever use a distributor or manufacturer's rep to finance equipment purchases during construction? How often?

3.4 It is well-known that contractors sometimes substitute equipment from the original specifications. What are all the reasons why a contractor might do this on a commercial or industrial job? *[e.g., save money, recommend brand with better maintenance record]*

3.5 In what percent of jobs does the owner or architect let you substitute equipment?
ENTER PERCENTAGE .... _____%

C.3.6 Installation

4.1 In what percent of commercial and industrial jobs did you install occupancy sensors in 1999? How about in 1996?

	1999	1996
ENTER PERCENTAGES	_____%	_____%

4.2 Of all your linear fluorescent installations, what percent were T12, T8, and T5 in 1999? And how about in 1996? (NOTE: CURRENT HIGHER PRIORITY THAN '96)

	1999	1996
1. T-12 Linear Fluorescent Lamps..............................	_____%	_____%
2. T-8 Linear Fluorescent Lamps................................	_____%	_____%
3. T-5 Linear Fluorescent Lamps................................	_____%	_____%
Total	100%	100%

4.3 Of all your linear fluorescent ballast installations, what percent were magnetic, electronic, and dimming in 1999? And how about in 1996?

	1999	1996
1. Magnetic Ballasts..	_____%	_____%
2. Electronic Ballasts...	_____%	_____%
3. Dimming Ballasts	_____%	_____%
Total	100%	100%

C.3.7 Promoting and Specifying

5.0 Have you had any formal training in lighting design or fixture selection and layout? (Please explain.)

5.1 In what percentage of jobs do you specify the equipment yourself? *(instead of the electrical engineer or architect)*
ENTER PERCENTAGE .... _____%

5.2 How often do you propose more energy efficient lighting options to your clients?
ENTER PERCENTAGE .... _____%

5.3 On a scale from 1 to 5 where 1 is not at all important and 5 is very important, How important do your commercial customers consider the following characteristics:
Initial cost of the equipment......................................_____
Total lifecycle costs \ energy efficiency....................._____

Quality of Light.._____
Ease of Maintenance ...._____

5.4 In terms of maintaining your firm's competitive position, how important is offering T8 lamps, electronic ballasts, compact fluorescent lamps, daylighting, or occupancy controls in your installations for existing buildings? Would you say ...

Very important 1
Somewhat important 2
Not very important..3
Not at all important 4

Now we would like to ask a couple of questions about the market for fluorescent lamps and ballasts in existing buildings

5.5 In approximately what percent of cases for existing buildings do you recommend or specify T8 lamps instead of or as an option to T12 lamps?

ENTER PERCENTAGE .... _____%

5.6 In approximately what percent of cases do you recommend or specify compact fluorescent lamps instead of or as an option to incandescent lamps?

ENTER PERCENTAGE .... _____%

5.7 Now I'd like to talk about occupancy sensors. What are all the reasons that might keep you from recommending occupancy sensors? [UNAIDED]

	Mentioned	Emphasized
First cost (including setup and tuning)		
Equipment reliability		
Potential for maintenance problems		
Customer's override/misuse of occupancy controls		
Commissioning/re-tuning costs		
Other:		

5.9 In general, what are the obstacles to increasing customer demand for installing high-efficiency lighting?

C.3.8 Controls and Daylighting

6.0 Are you familiar with the process of using daylight to reduce electric lighting usage? [IF NO, then provide brief explanation]

Yes..1
No...2

6.1 On roughly what percentage of your lighting projects, if any, have you installed daylighting controls and/or dimming ballasts over the past two years?

ENTER PERCENTAGE .... _____%

IF 0%, SKIP TO 6.3

6.2 And in those cases in which you installed daylighting controls and/or dimming ballasts in the past two years, how satisfied were you and your clients with the performance of the systems? PROBE ON ANY PROBLEMS

6.3 What do you think are the biggest hurdles to keeping daylighting from being used more? [DO NOT PROMPT]

Fragmentation of specialties..1
Climate too cloudy 2
Extra equipment cost..3
Extra labor cost 4
Glare problems 5
Thermal compromise (overheating or cooling).....................6
Need for follow-up maintenance and re-tuning....................7
Other (Specify)______________________.....................8

6.4 What are all the reasons that might keep you from recommending a daylighting design that reduces lighting energy use with dimming or other controls? [UNAIDED]

	Mentioned	**Emphasized**
First cost		
Equipment reliability		
Potential for maintenance problems		
Customer's lack of awareness of dimming controls		
Customers' lack of information about dimming controls		
Other:		

6.5 What improvements or changes do you think need to be made to increase the use of daylighting?

6.6 How interested, if at all, would you say your firm is in doing more work with daylighting systems?

Very interested..1
Somewhat interested..2
Not interested..3
Don't know / No answer..9

C.3.9 Suggestions

7.1 Which, if any, new or emerging lighting technologies or practices do you think are most promising? (Clarify, not restricted to those mentioned in this survey.)

7.2 What sources do you typically use to keep abreast of new lighting technologies? *[Unaided]*

Other lighting contractors 1
Architects 2
Distributors...3
Manufacturers..4
Trade magazines..5
List:________________
Websites 6
List:________________
Trade shows (e.g. Lightfair) 7
List:________________
Northwest Lighting Lab...8
PGE Lighting Lab...9
Other: _______________________________________ ... 10
Don't Know 11

7.3a Are you aware of the Lighting Design Lab in Seattle?

Yes..1
No...2

7.3b [If YES] Have you ever been to the Design Lab?

Yes..1
No...2

7.3c Have you ever used any of the services offered by the Design Lab?

Yes..1
No...2

7.3d [If YES] Which services have you used?

Consultations 1
Mock-up facilities 2
Classes 3
Tours 4
Daylighting simulations 5
Other, Specify______________ 6

7.4a Have you ever used the website www.lightsearch.com?

Yes...1
No..2

7.4b [If YES] Have you ever you ever used any of the services offered by the www.lightsearch.com?

Yes...1
No..2

[IF Yes] Which services?

7.5 Do you have any ideas for initiatives in energy efficient commercial lighting that could be pursued by the Northwest Energy Efficiency Alliance?

Close: This research is sponsored by the Northwest Energy Efficiency Alliance. The Northwest Energy Efficiency Alliance very much appreciates your participation in this research and values your insights.

7.6 The Alliance is considering new initiatives in commercial and industrial lighting and may be seeking firms and individuals to participate in an lighting advisory group in the future. Is this something in which you or your firm would be interested in participating?

Yes...1
No..2
Name: ______________________ Phone: ______________________

THANK FOR PARTICIPATION