larger integrated programs including other end-uses (because many evaluations focus on energy more than peak) and in part because evaluations tend to focus more on total savings than percent of load saved. However, savings from small C&I retrofit programs are often on the order of 10% of total building (for all electricity uses) energy and peak load. In 1999, Massachusetts Electric’s (National Grid’s largest subsidiary at that time) small C&I program saved an average of 2.2 kW/customer from lighting measures, and an additional 0.2 kW from other measures (National Grid 2000c).

For larger buildings, the savings from lighting ranges from 10–20% of lighting load, and in many cases even higher, depending on the breadth and depth of the retrofit. EPA’s program has commonly found it possible to reduce lighting loads by 30–50% (EPA 1999). In 1999, Massachusetts Electric’s Energy Initiative retrofit program saved an average of 4.7 kW/participant with lighting measures.

While evaluation issues are beyond the scope of this report, it is important to recognize that lighting-connected load reductions do not precisely match nameplate ratings (Gordon, Quaid, & Gardner 1995). For example, lamp/ballast interactions must be considered, which will sometime increase and sometimes decrease consumption relative to nameplate ratings. Similarly, not all lights are on (therefore saving energy) during peak periods. For example, New England Electric’s (now National Grid) study of lighting measures in new buildings using lighting loggers estimated diversity factors in the range of 77–80% during peak hours (New England Electric 1994). Also, the most common technique for estimating lighting energy savings is to multiply lighting load reductions (in watts) times annual operating hours. Several utilities have conducted studies in which they install meters or light-sensing loggers of some type in a sample of buildings. A recent review of nine of these studies, covering on-site measurements at 367 sites, found average annual operating hours of 4005 (Miller 2000).

In addition, since lighting energy savings reduces the heat produced by lighting systems, savings estimates should include reduced air conditioning load due to less heat produced by lights, and the corresponding increase in heating load for facilities with electric heat. Cooling benefits will be higher and heating benefits lower in warmer climates, and the reverse holds for cooler climates. The particular effects vary by region and building type. A recent set of analyses by Lawrence Berkeley National Laboratory examine these impacts in detail (DOE 2000c provides the most recent estimates by building type at the national level; Sezgen and Huang 1994 provide regional data but their numbers are subject to some shortcomings noted in the 2000 report).

Finally, there is the issue of freeriders, meaning customers who participate in a program but would have installed efficiency measures anyway. Some of the most recent estimates of freerider levels for lighting upgrades are provided by a National Grid 1999 survey of participants in its programs. For lighting retrofit measures, National Grid found that freeriders were 0–2.5% of its
small customers and 3–5% of its large customers. The low end of the range signifies participants who are clearly freeriders; the high end of the range includes “partial freeriders,” which are customers who claim they would have made the improvements eventually but not necessarily soon (National Grid 2000c). Also, as the new DOE ballast standards kick-in after 2005, these long-term partial freerider levels will increase (i.e., incentives provided in 2001–2004 will merely accelerate adoption of electronic ballasts that would have been sold in the post-2005 period.

**Cost**

In 1999, Massachusetts Electric's large C&I retrofit program, Energy Initiative, provided the following savings:

<table>
<thead>
<tr>
<th></th>
<th>Prescriptive Lighting</th>
<th>Custom Lighting*</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak MW</td>
<td>4.1</td>
<td>0.4</td>
<td>4.5</td>
</tr>
<tr>
<td>MW years</td>
<td>78</td>
<td>6</td>
<td>84</td>
</tr>
<tr>
<td>Annual GWh</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Lifetime GWh</td>
<td>306</td>
<td>44</td>
<td>350</td>
</tr>
</tbody>
</table>

*Includes lighting controls.

National Grid does not report cost-effectiveness by end-use. However, the overall cost of program implementation, including non-lighting measures, was $1,013/kW and $65/kW-year (undiscounted — i.e., annual kW x measure life), and 1.3 cents/lifetime kWh (cost/lifetime kWh). The lighting measures were among the more peak-intensive and less expensive, so we can only assume that they cost less per kW (National Grid 2000c).

Lighting savings from Massachusetts Electric's small C&I program in 1999 can be summarized as follows:

<table>
<thead>
<tr>
<th></th>
<th>Prescriptive Lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak MW</td>
<td>2.7</td>
</tr>
<tr>
<td>MW years</td>
<td>39</td>
</tr>
<tr>
<td>Annual GWh</td>
<td>6</td>
</tr>
<tr>
<td>Lifetime GWh</td>
<td>83</td>
</tr>
</tbody>
</table>

The overall cost was $1,134/kW, $78/kW-year, and 3.5 cents/kWh. These figures include non-lighting measures, which are more expensive, and so are probably slightly high. However, this program, and its costs, are dominated by lighting measures. Much of the higher cost/kW (compared to Energy Initiative’s program) is due to higher marketing and installation costs due to the small savings at each site. This is balanced by the fact that small buildings tend to have fewer freeriders because customers less frequently upgrade efficiency on their own (National Grid 2000c).
A review of the largest lighting programs in the country found that the majority of programs had total costs below 4.4 cents/kWh saved and utility costs below 3.1 cents/kWh. Four programs had costs of about 2.0 cents/kWh saved or less (Eto, Kito, & Sonnenblick 1995).

**Non-Energy Benefits**

The program would also replace many lighting fixtures that were providing inadequate light and in some cases reaching the end of their useful life. Quality of lighting could be increased or decreased depending on the quality control regime employed by the program sponsor and the quality of lighting contractors and equipment employed.

**Measure Life**

Controls aside, the life of most lighting measures depends on the time that the fixtures remain in place. The most thorough study of which we know estimated life for a large sample of in-service fixtures. Even in an area with high building growth, the average life was 21 years (Skumatz 1994).

Control measures may have different lives depending on the durability of the sensors and equipment. National Grid estimates a 10-year average measure life for occupancy sensors.

For ballasts installed without new fixtures, life is best measured in hours of use since annual hours vary significantly from building to building. Generally, the equipment rating for specific equipment is useful. One study found a typical life of 70,000 hours (Gordon et al 1988).

**Market Penetration**

This would depend on what has already been done locally. High-volume programs have addressed as much as 5% f the total market per year for a number of years. A few very high-incentive programs may have moved faster for individual years (Edgar, Kushler, & Shultz 1998), particularly those operated by smaller utilities that intensively cultivated community involvement (Holt, Gordon, & Tumidaj 1995).
6. Commercial and Industrial Lighting Design Enhancement Program

Overview

The purpose of this program is to capture savings by using equipment and design practices that are more efficient than standard practice in commercial and industrial new buildings, renovations, and remodels. Lighting loads are the key determinant of commercial building peak. Design enhancements beyond current practice could radically reduce peak lighting load in some facilities if both efficient lighting technologies and daylight harvesting were employed. Simple approaches could save an additional 10%. In the best cases, the majority of lighting load would be eliminated.

The lighting design enhancement program would support and be enhanced by efforts to achieve state-level adoption and enforcement of the lighting standards in the new ASHRAE 90.1-1999 standard. It would also encourage efficiency beyond that standard. In states where the ASHRAE code has not yet been adopted, an effective program could increase the odds of acceptance. In states where the code has been adopted, the program could enhance compliance and assure that compliance results in quality lighting systems. In these states, the program could also lay the groundwork for possible future code upgrades.

The program design capitalizes on efforts of pioneering utilities and regional efficiency organizations to develop specific tools to work with the design community. The central structure of the program is a series of custom and prescriptive incentives, supported by a program of technical assistance. The proposed rebates are similar to those in the retrofit acceleration program described above except that:

1. They are keyed to improvements beyond current practice and codes;
2. The custom rebate takes a larger role; and
3. Rebate levels are based on a portion of the incremental cost to exceed current practice and codes, whereas the retrofit acceleration program bases rebates on a portion of full cost.

A special track is recommended for smaller and contractor-designed buildings. In these buildings, lighting design tends to be simple and standardized. Contractors rarely analyze lighting system energy use or light output. For these buildings, the program proposes lighting design guidelines that would be used both to train contractors and to build demand for better lighting among owners, managers, and renters. The guidelines would also create a template for distributors, manufacturers, and other "contractor helpers" to specify efficient, high-quality layouts. Marketing for the guidelines should be targeted at contractors and designers through their associations and through alliances with manufacturers. Training should be held on the
guidelines. A series of demonstrations, funded in part through the incentives discussed above, should be individually evaluated, documented, and published, and used as a tool to help build acceptance of the guidelines.

Target Market

This program is targeted at new construction, renovation, and “hard remodels,” which involve changing lighting layouts or fixtures.

The “custom design” track is targeted at large buildings where lighting systems are custom-designed. Key targets would include architects, engineers, and lighting designers, including both consultant designers and design professionals working within property development/management organizations. In-house professionals often exist within chains and owner/manager firms specializing in office and retail rental space. Early adopters have often included high-profile office and institutional spaces.

The “small and simple building design” track focuses on buildings where designs are typically copied from site to site with little or no analysis. These include many industrial spaces, smaller and rental office and retail space, and schools. Schools are something of an anomaly in that they are often designed with the help of an architect, but lighting designs are seldom changed from site to site. Thus, the architects who specialize in this work may pay little attention to the lighting system, and may be responsive to comparative tools and approach as the contractors who do not employ a design professional.

Efficiency Measures

A variety of design approaches should be employed, including:

- Elimination of over-lighting and more efficient provision of lighting through fewer, higher-quality fixtures, fewer lamps, designing lighting to focus on areas of use, and better specification of ballast factor.
- More appropriate lighting fixtures for coves and coffers.
- Alternative approaches for accent lighting.
- Additional applications of compact fluorescent lamps beyond those that are commonplace today.

20 These could include T-5, T-8, IR halogen, and many other types of lamps, within fixtures designed to take advantage of the optical properties of each lamp.
• Use of compact fluorescent lamps with electronic ballasts instead of magnetic ballasts.

• More and better use of dimmers, especially daylight-modulated dimmers, occupancy sensors, and timers.

• Task lighting and indirect lighting to reduce required room lighting levels.

• Individual occupant controls over lighting (through addressable fixtures) — a promising new innovation that may significantly reduce energy and peak use.

• Consideration of specialized controls in peak-constrained areas in order to reduce ambient lighting during extreme peak periods. Such controls may prove to be extremely profitable for owners.

• For smaller buildings, especially for remodels, incentives may still be justified for T-8 lamps and electronic ballasts. Current practices vary locally, but these markets appear to be among the last to adopt these technologies.

Many of these measures involve higher-quality fixtures, more diverse fixtures, and more controls than are commonly being used today. The payoff would be a more aesthetically pleasing and functional space as well as lower energy use.

Program Strategies

Design enhancement is new to many program sponsors, but others have been working with the design community for many years. Some sponsors are concerned that they should not "second guess" designers, essentially taking over the task and liability for adequacy of lighting design. Leading utilities have successfully developed design assistance and incentives that empowers designers by providing them with more information, tools, time to design, and the ability to present efficient options to their clients with modest added cost and clear user benefits.

For lighting design improvements, market barriers are summarized in Table C-17.
### Table C-17. Market Barriers to Commercial and Industrial Lighting Efficiency through Design Enhancement

<table>
<thead>
<tr>
<th>Market Barrier</th>
<th>Key Issues</th>
</tr>
</thead>
</table>
| **Customer Access to Information**  | • Most customers are unfamiliar with design approaches to lighting quality and efficiency.  
• Customers often do not know how much light they need, so they are conservative about reducing lighting levels. They also often do not know that quality reflectors and fixtures could improve light distribution.  
• Customers sometimes are not familiar with the connection between lighting quality and occupant performance issues such as worker output, retail sales, and student performance.  
• Many customers do not have unbiased sources of information and lack the time and confidence to perform quality assurance on lighting design. It is particularly difficult for them to know which designers have expertise in designing to specific levels of quality for specific types of applications.                                                                                   |
| **Customer Internal Issues**        | • In construction projects, lighting is considered a detail. It needs to “work” and then key personnel need to attend to other things.  
• Many customer organizations (small and large) have not assigned responsibility to an individual to carry out efficiency measures. This hampers decisions and limits expertise.                                                                                                    |
| **Product Definition**              | • “Quality lighting design” is not well-defined for designers, and especially for users. It involves extensive aesthetics and judgement. This makes it harder for customers to identify, desire, purchase, and verify quality designs.                                                                                   |
| **Trade Ally Issues**               | • Contracting processes are diverse, but generally favor lower bids. Unless quality is a requirement in a bid, quality proposals are risky.  
• Given limited developer interest and budgets, the conservative approach is to “design it like I did last time.”  
• Smaller buildings are not designed — they are often copied from templates or prior designs. The design process often consists of a counter-top or cell phone discussion with the manufacturer’s or distributor’s representative.  
• Contractors may be trained to follow more complex strategies and layouts, but the changes must be presented gradually, within the context of their existing practice.  
• Even for many larger structures, architects and engineers copy the last design that passed muster, adjusting as necessary for codes or special needs. While skills are higher than among small building contractors, the culture is not oriented towards analysis or efficiency.  
• Many designers regard efficiency as a “design constraint” more than a design value. They do not regard it as a tool for enhancing their value or winning jobs.                                                                 |
| **Financial Barriers**              | • In many organizations, financial managers do not regard efficiency as a source of revenue or major savings; their attention is on maximizing revenue as a higher priority than cutting costs. Energy costs are swamped by other factors in purchasing decisions.  
• Efficiency improvements are often “value engineered” out of construction projects to assure that funds are focused on more visible problems, critical code issues, etc.  
• In large organizations such as state and federal governments and multi-site corporations, the corporate unit that pays for construction often is not the unit that pays energy bills, and the two do not communicate effectively about management of costs.  
• Many developers provide a “build-out allowance” for lighting for tenants, which restricts investment in quality lighting.                                                                                      |
| **Design Methods and Values**       | • Some buildings are designed to be as flexible as possible to meet the needs of tenants who may change. Flexibility could lead to generic over-lighting if not carefully thought through.                                                                                                                      |
While awareness should be the first program barrier addressed, the most crucial barrier will be product definition. Lighting design is not a commodity like a ballast. Lighting design is a package of enhancements to selection, placement, and control of a wider variety of equipment than a lighting contractor normally considers. Good lighting design is more complex to ask for or offer, so it is more difficult to establish a market where the buyer understands what is being sold and can verify its legitimacy. Even efficiency-oriented designers don't always agree on the "best" approach to a space. As a consequence, efficiency and quality would be considerations for a select group of elite designers for elite buildings where the clients are looking for ways to distinguish their building.

Detailed discussions with members of the lighting design community have revealed that energy efficiency will never be a high priority for their work (Gordon, Tumidaj, & Coakley 1995). Thus the primary focus of this lighting design enhancement program is on enhancing the market position of "high quality lighting" as a valued, salable, and verifiable commodity.

There have been significant efforts in recent years to address these barriers, ranging from development and promotion of quality/efficient lighting guidelines for contractors, more complex lighting guidelines for high-end designers, lighting demonstration and training facilities, contractor certification, federal branding programs (ENERGY STAR), etc. At the moment, the profusion and lack of coordination of these effort creates an additional barrier to more interested developers, designers, and owners. The proposed program tries to create a "tree" to incorporate all of these appropriate experiments in a way that is coherent to customers and manageable for program sponsors.

Technical Assistance

For buildings where designers are involved, the program should offer both direct technical assistance and reimbursement to contractors for the extra time involved in efficient equipment analysis and design.

For high-end buildings, technical assistance could be provided using the system currently employed with minor variations in several of the more ambitious utility new construction programs (e.g., National Grid, NSTAR, Northeast Utilities, and Conectiv Power Delivery). These programs offer modest compensation to designers for the added cost of considering efficient equipment, and also offer the services of "efficiency expert" contractors to work with designers.

For example, Conectiv Power Delivery of New Jersey (Conectiv) offers up to $2,000 to compensate for analysis of a lighting system that results in a high-quality design, subject to several conditions to assure that the design exercise is effective and necessary. A contractor working for Conectiv will also assist with advice on lighting system design, including:

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- Plan review and analysis of energy efficiency options
- Walk-through audit of current facility
- Consultation on selecting and specifying energy efficiency measures
- Basic design assistance (small new construction and/or remodeling)
- Basic measure/system/project analysis and recommendations
- Assistance with incentive applications and program compliance

Some customers rely more on Conectiv Power Delivery's contractor, and others rely more on their own designer, compensated in part by the utility. Conectiv also offers higher incentives for efficient design work involving multiple end-uses. Details are available at Conectiv's Web site (Conectiv 2000b).

For smaller and simpler buildings, there really isn’t much of an existing design process to influence. Contractors typically take designs from prior designs or “templates” or work with suggestions provided by the lighting distributor’s or manufacturer’s salesperson. There is little or no numerical analysis. The Design Lights Consortium (DLC), a group of utilities and other conservation proponents in the northeastern United States, has developed an initiative to directly address this market. Their KnowHow series of lighting design guidelines (DLC 2000) are the centerpiece of this campaign. These guidelines are intended to help create excitement about quality efficient design among contractors and their clients. The guidelines offer “good, better, and best” approaches to lighting design for ordinary commercial spaces. The “good” level is generally not much more efficient than the recently passed ASHRAE lighting standard but assures reasonable lighting quality while meeting the standard. “Better” and “best” standards incorporate progressively higher-quality and more efficient lighting.

The first three guidelines (small office, small retail, and school) are about a year old and have been used in several training classes and several demonstration projects. Three case studies are available (DLC 2000). They have generated significant excitement among both manufacturers and contractors. They are currently being incorporated into code compliance training in Massachusetts. While contractors seem to be using some of the information from training in the guidelines, the extent of their influence is not yet clear. An evaluation is currently being planned. Also, additional guidelines are being developed for industrial lighting and for skylighting in retail and industrial buildings.

The case studies are used to demonstrate how to apply the guidelines, and the case study process is showing some of the complications of marketing high-quality lighting. Because the focus is on quality, the equipment recommended in the guidelines cost more than simple cheap fixtures that could provide efficiency. However, the guidelines assure that the lighting levels meet user needs, and hopefully can create more of a market demand for better lighting for ordinary buildings.

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Based on very early feedback, it could prove useful to have additional informational pieces to make the guidelines attractive for purchase and leasing agents (i.e., a shorter “sell” piece”) and to help contractors actually lay out conforming lighting systems (i.e., case studies and manufacturer-provided model layouts). However, the guidelines appear to offer the core for a potentially effective approach to “next wave” lighting for smaller buildings. DLC is actively recruiting manufacturers as allies and encouraging them to develop conforming model layouts.

We recommend that sponsors who wish to promote good lighting in small buildings work with the DLC to access their guidelines and help them evolve. In addition, we recommend that sponsors offer training workshops in use of the guidelines, provide custom incentives (as described below) to help get a number of buildings in the field that conform to the guidelines, and develop local case studies. Additionally, the sponsor’s technical assistance staff could help contractors through their first few experiences in designing guideline-conforming buildings.

Marketing

The long-range market strategy for this Lighting Quality Enhancement program is to influence the market so that customers are motivated to purchase high-quality efficient lighting for reasons of appearance and functionality, with reduced demand and energy use as a secondary consideration. However, in the short run, many sales could also be made based on energy savings re-enforced by utility incentives. Neither the “quality” nor the “energy savings” approach would work everywhere.

Critical marketing targets would include:

- Designers (mostly architects, engineers, and professional lighting designers for larger and high-end buildings and schools, mostly contractors with limited technical background for smaller and low-priced buildings)
- Developers
- Purchasing, and rental agents within customer organizations
- Personnel who upgrade buildings for rent within property management firms

A keystone to marketing would be demonstrating that quality lighting helps meet developer objectives, such as faster rentals and sales, higher occupancy, higher rents, more satisfied and productive occupants, higher retail sales volume, etc. A national consortium is working to develop information on productivity benefits of efficient lighting (Light Right Consortium 2000). An influential set of studies demonstrating productivity benefits of quality lighting in retail schools (better grades) and retail buildings (better sales) is available (Heschong, Wright, & Okura 2000; Okura, Heschong and Wright 2000).
A more direct approach to showing non-energy benefits would be to conduct "impressions research." This would amount to encouraging personnel who make purchase and rental decisions to tour buildings that meet quality lighting standards and then through other buildings that are similar except that they do not meet those standards. The impressions of real buyers and rental agents (assuming that they prefer quality lighting) would likely make a very direct impression on their peers.

Communications materials should be crafted for contractors, designers, engineers, developers, rental agents, etc. For designers and contractors, professional associations would provide useful allies and leverage points for communication. However, significant one-on-one in-person communication would be necessary to help designers adapt new approaches.

With respect to the lighting guidelines, DLC has developed a detailed marketing plan for 2000. Training, trade ally alliances, trade shows, and direct contact are among the approaches being applied.

The retrofit acceleration program described above might also provide a marketing avenue. Through the custom retrofit incentives proposed for that program, there would be an opportunity to promote advanced lighting designs. However, it is important that very simple approaches should also be available under that program to meet its primary purpose — capture of high-volume, near-term savings.

**Financial Incentives**

For both the "custom design" and "small and simple building design" tracks, a number of utilities offer cash incentives to help defray the cost of more efficient lighting equipment in new buildings, renovations, and remodels. These incentives typically pay a portion of the incremental cost of more efficient equipment. Traditionally, these incentive strategies have focused simply on efficiency, and incentives have been structured to sell adequate lighting quality, not superior quality.

Many of the "next wave" lighting strategies require redesign of fixture layouts. Beyond a point, reduction in lighting intensity is possible only with higher-quality components and new layouts to provide more-available and better-distributed light. In some cases, the components would be affordable only if the customer considers the improved "look" of the space to be an asset that helps justify the cost.

For these reasons, one-for-one equipment incentives, while valuable, would be secondary for this program. The centerpiece of the incentive strategy is custom incentives, which would help pay for any measures that the sponsor deems to be acceptable. Since much of the value would come from intangible improvements to the "look" of the space, typical cost-effectiveness
screening would not be useful; while the non-energy benefits have been demonstrated in research studies (as discussed below), they would be too difficult to quantify on a site basis. If these benefits weren’t considered, many measures that would be appropriate would be eliminated from programs.

Sponsors would have an option of two strategies toward prescriptive incentives. First, some utilities have tried to push as many measures into prescriptive rebates as possible. This is done for two reasons:

- Minimize the delay and expense of a custom calculation for every site.
- More clearly promote classes of efficient product for different types of common practice fixtures.

National Grid clearly falls into this camp. Its prescriptive rebates are downloadable in Adobe Acrobat from their Web site (National Grid 2000a). Rebates are available for a variety of high-quality fixtures, LED exit lights, and controls. Payments are generally established per unit of equipment. Minimum watts per control unit are specified, as are acceptable power factor and harmonic distortion. Incentives are designed to cover the majority but not all of the incremental cost of hardware alternatives.

Other utilities have chosen to rely more on custom incentives. Prescriptive rebates are used only for customers who are unlikely to utilize the more complex custom format (i.e., small buildings and specific industrial opportunities) or for measures where the watt/kW incentive does not work well (i.e., controls).

This approach keeps the program materials relatively simple for the newcomer, and has less tendency to drive designers toward specific solutions. For a small program sponsor, it is resource-intensive to keep a diverse set of prescriptive incentives current.

Conectiv provides an example of this approach. Their incentives and conditions are available from their Web site (Conectiv 2000a). Prescriptive incentives are provided only for:

- T-8 lamps and electronic ballasts in new buildings under 50 connected kW and remodels of facilities under 100 kW ($10)
- Hardwired compact fluorescent lamps in the same classes of smaller buildings ($2.35–$18.25, depending on the size and type)
- Occupancy sensors ($15/fixture, up to cost of sensor)
- Daylight dimming ($15/fixture up to cost of the sensor and controller)

Based on experience working with Conectiv Power Delivery, we recommend a custom incentive that pays $1/watt for reductions in lighting use below established baselines. The
intention would be to pay the majority, but not all, of the costs of efficient equipment. It might not pay as large a share of the costs for the highest-quality equipment, but the goal is to sell that equipment based on lighting quality improvements as well as energy savings.

Either the prescriptive or the custom approach would work. We believe that the National Grid approach is superior for sponsors who would be willing to invest the time and expertise in keeping a diverse set of rebates up-to-date and working with contractors to understand the various rebate options. However, the Conectiv system has worked well for it. The system has required that the implementation contractor perform more site-by-site work, but the contractor has developed streamlined procedures for doing this.

To estimate incremental cost for custom measures and establish lists of rebate measures, it would be necessary to establish a design baseline. For states where design is fairly advanced from an energy standpoint or where the ASHRAE 90.1-1999 standard (or similar) has been implemented, the lighting power densities in that standard could provide a baseline. Where building codes have not been upgraded in many years, or are not thoroughly enforced, the baseline could be somewhere between the old ASHRAE code and the new ASHRAE code. For example, after reviewing recent building designs, Conectiv elected to pay incentives for lighting designs with lighting power densities 30% more efficient than the older ASHRAE 90-1989.

**Financing**

For new construction, we do not believe that direct utility financing is critical. The sort of financial referral service and close coordination with energy service companies described for the retrofit acceleration program (described above) would sometimes be useful, especially for remodel and renovation projects.

**Quality Control**

Sponsors should provide quality control similar to that for the retrofit acceleration program. They should also track incremental costs of equipment in the market to assess whether incentives continue to be appropriate or need modification.

For the case studies, sponsors should confirm that designs meet the guidelines. Individual sponsors or DLC should review material from manufacturers or others that portends to conform to the guidelines. As of this writing, the DLC is trying to forge alliances with market actors, which should help in this regard.

**Relationship of Program Strategies to Market Barriers**

These are summarized in Table C-18.
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Table C-18. Market Barriers and Intervention Strategies for Commercial and Industrial Lighting Design Enhancement Program

<table>
<thead>
<tr>
<th>Market Barrier</th>
<th>Intervention Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Access to Information</td>
<td>- Utility staff and contractor technical assistance</td>
</tr>
<tr>
<td></td>
<td>- Marketing and educational materials for customers to help them understand the benefits</td>
</tr>
<tr>
<td></td>
<td>- Marketing through contractors</td>
</tr>
<tr>
<td></td>
<td>- Technical studies where needed</td>
</tr>
<tr>
<td>Customer Internal Issues</td>
<td>- Utility/sponsor quality control</td>
</tr>
<tr>
<td></td>
<td>- Design guidelines for contractor-designed jobs</td>
</tr>
<tr>
<td></td>
<td>- Prescriptive equipment recommendations</td>
</tr>
<tr>
<td></td>
<td>- Demonstration of how to build quality specifications into lighting bids and what to expect from contractors</td>
</tr>
<tr>
<td>Product Definition</td>
<td>- Establishment of baseline practices</td>
</tr>
<tr>
<td></td>
<td>- Clear branding (through guidelines) to help customers and developers focus</td>
</tr>
<tr>
<td></td>
<td>- Training and technical assistance</td>
</tr>
<tr>
<td></td>
<td>- Design guidelines for contractor-designed jobs</td>
</tr>
<tr>
<td></td>
<td>- Case studies to show designers that lighting efficiency and quality are compatible</td>
</tr>
<tr>
<td>Trade Ally Issues</td>
<td>- Creation of demand for lighting quality so firms want to learn how to provide it</td>
</tr>
<tr>
<td></td>
<td>- Simplified, guideline-driven approach for smaller buildings; technical assistance for custom jobs</td>
</tr>
<tr>
<td></td>
<td>- Assistance for smaller contractors in advancing a step at a time</td>
</tr>
<tr>
<td>Financial Barriers</td>
<td>- Incentives for efficient designs</td>
</tr>
<tr>
<td></td>
<td>- Case studies showing financial benefits, both energy and non-energy. Focus on sales and leasing benefits for developers and property managers.</td>
</tr>
<tr>
<td></td>
<td>- Direct work with government entities to develop channels for funding efficiency</td>
</tr>
<tr>
<td>Design Values</td>
<td>- Case studies of flexible designs that meet needs of rental properties</td>
</tr>
</tbody>
</table>

Key Indicators of Success

The indicators of success for lighting design enhancement programs would include the following:

- Interest in the guidelines among businesses and contractors (an early indicator)
- Increased broad interest in quality design
- Peak and energy savings
- Support by professional groups (another early indicator)
- Attendance at training sessions (a second-stage indicator)
- The square footage of target market that is built/remodeled using lighting guidelines (for the third year and beyond)
- The extent to which contractors and others rely on lighting guidelines (throughout the project)

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- The extent of customer satisfaction and demonstrated non-energy benefits from the use of the lighting guidelines in pilot projects (once case studies are in place)
- The extent to which the lighting design community supports and implements incorporating the lighting standards in the new ASHRAE code into local and state codes

In addition to these market indicators, it would be prudent to conduct some evaluation, including use of metered data, for maturing technologies and those where savings would be sensitive to design, installation, and operation (e.g., controls, particularly daylighting).

Cost and Benefits

Savings

Savings would be highly dependent on baseline practices. The previously cited study of baseline lighting practices in New Jersey (Sardinsky 2000) developed rough estimates of potential additional savings by building types as follows:

- Retail: 5–25% (sample of 13)
- Offices: 5–30% (sample of 9)
- Warehouse: 40% (sample of 1)
- Schools: 10–25% (sample of 2)
- Nursing homes: 15–30% (sample of 4)
- Lodging: 10–20% (sample of 1)
- Hospitals: 25–35% (sample of 2)

Significantly, most of these buildings had already incorporated “basic” efficiency measures such as T-8 lamps, electronic ballasts, and compact fluorescent lamps. The variation within building type reflects both building-to-building variation and some uncertainty regarding the estimates. While this analysis addressed energy savings, most of the savings were from measures with proportional energy and peak effects.

Lighting energy savings also produce cooling energy savings, which vary depending on local climate. As discussed above in the discussion on the lighting retrofit acceleration program, these interactions vary by climate and building type and Lawrence Berkeley National Laboratory developed factors to adjust for these interactions by region and building type.

Other Benefits

Customer benefits were introduced under “Marketing,” above.
One additional benefit of acceptance of high-quality lighting from a utility perspective is a higher likelihood that lighting market actors would not resist passage or implementation of an advanced lighting code such as one based on the recently passed ASHRAE standard.

From the point of view of contractors, high-quality lighting provides a way to differentiate themselves in the market, and a way to sell higher-priced quality equipment. This generally provides higher gross profit. Manufacturers would also benefit by selling high-quality, higher-cost equipment.

Cost

Costs for additional lighting design depend strongly on the approach. The DLC approach (for smaller and simpler buildings) is a market transformation approach, and assumes that the quality of the lighting would help sell higher levels of efficiency. Therefore, the capital cost of conforming to the DLC approach is relatively expensive, but not all the costs are attributable to efficiency. We expect that costs will decrease as standardized approaches evolve for conforming to the guidelines and high-quality equipment costs drop due to volume and competitive pressures. An example is provided by pendant indirect fixtures. One manufacturer decided to create a mid-priced line for these previously “high-end” fixtures. Now several manufacturers offer mid-priced lines at significantly lower cost than those of two years ago (Sartinsky 2000).

For larger, more complex buildings, utilities such as National Grid and Northeast Utilities have been able to pay incentives at a lower cost/kWh than their avoided costs of energy and peak power. Savings and costs for National Grid’s Design 2000 program for new construction and equipment replacement are shown below in Table C-19 (National Grid 2000a).

<table>
<thead>
<tr>
<th></th>
<th>Prescriptive Lighting</th>
<th>Custom Lighting*</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak MW</td>
<td>1.6</td>
<td>0.2</td>
<td>1.8</td>
</tr>
<tr>
<td>MW years</td>
<td>25</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>Annual gWh</td>
<td>10</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Lifetime gWh</td>
<td>153</td>
<td>15</td>
<td>168</td>
</tr>
<tr>
<td>Cost/kW-year/kW**</td>
<td></td>
<td>$1,605</td>
<td></td>
</tr>
<tr>
<td>Cost/lifetime kW**</td>
<td></td>
<td>$96</td>
<td></td>
</tr>
<tr>
<td>Cost/lifetime kWh**</td>
<td></td>
<td>$0.02</td>
<td></td>
</tr>
</tbody>
</table>

*Includes lighting controls.

**Includes non-lighting measures

Because these figures incorporate more expensive measures from non-lighting end-uses, the costs for lighting are likely dramatically overstated. It is also important to bear in mind that historically, the cost for the new technologies in the program (e.g., electronic ballasts) have
come down over time as they became commodities. This is likely to occur for the technologies currently being promoted.

There are also costs to running the training, developing the guidelines, etc. as DLC is doing as of this writing. Those costs have run around $900,000 for the Design Lights Consortium as a whole over the past 2 years. This amount was spread among six retail utilities to begin with (currently nine) and one state conservation entity. The amount includes about $200,000 for demonstrations, which provide savings but are more expensive per kWh than ordinary program activity because they are designed as showcases and are also learning sites for the program (Dagher 2000).

**Measure Life**

See retrofit acceleration program description above.

**Possible Market Penetration Rate**

While there are huge variations, lighting fixtures are on average replaced every 21 years (Skumatz 1994). In an area with a 4% growth rate, the potential market would be 41% of the lighting equipment stock in place at the end of the 5th year.21

Possible rates for penetration into this target stock are shown in Table C-20. The long-term rate is based on participation rates in five of the most successful commercial new construction programs (Nadel, Pye, & Jordan 1994).

<table>
<thead>
<tr>
<th>Table C-20. Penetration of Lighting Design Enhancement Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>1%*</td>
</tr>
</tbody>
</table>

*Largely for developing administrative system and relationships, training, and case studies.

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21 \((1.04(\text{fifth power})^{-1}) + (1/21x5)/1.04(\text{fifth power}) = 41\%\).