# Lighting the Way to Best Practices

*Carol Jones, Tracy Beeson, and Ruth Taylor, Pacific Northwest National Laboratory*

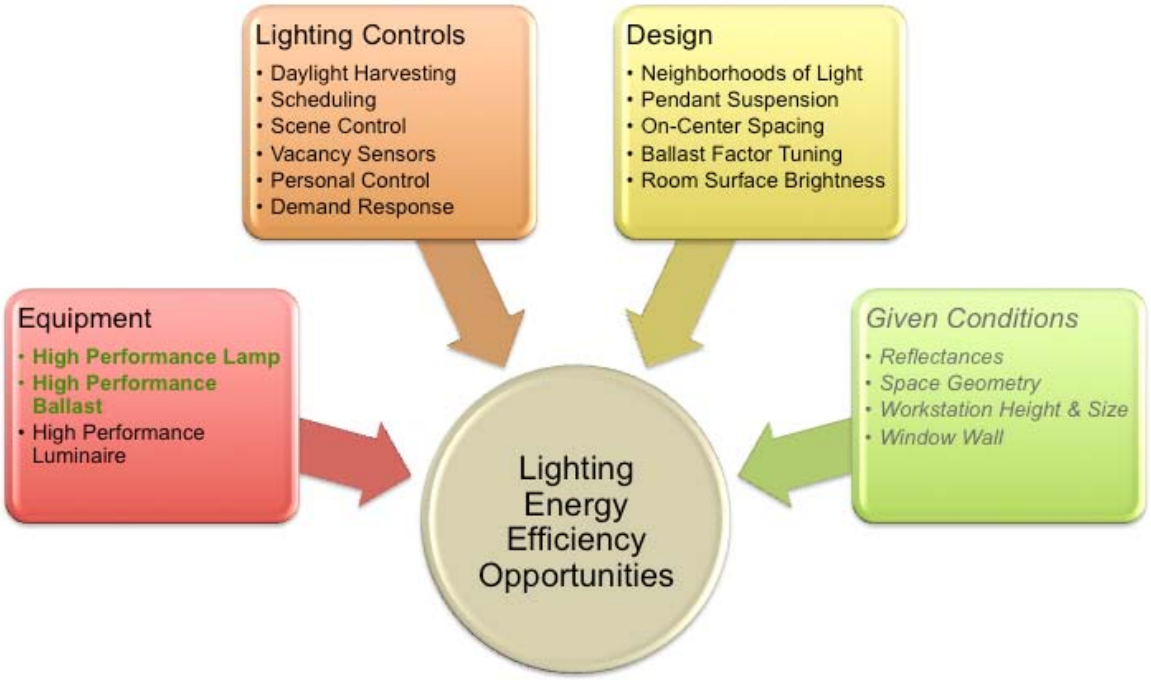
**ABSTRACT**

Commercial programs that aim to achieve deep energy savings must go beyond "technical correctness," they must be holistically designed to meet the needs of multiple audiences including owners, designers, manufacturers, installers, and energy program managers. This partnership-oriented and comprehensive approach is the strategy behind a USDOE program that works with all the players to provide integrated best practice lighting solutions for commercial buildings. Delivery and tracking is accomplished via a web-based interactive platform, which estimates energy savings progress against a user-chosen baseline. The web application provides multiple well-designed energy-efficient lighting solutions using high performance products, daylighting, and controls. In its third year, the program is maturing at exactly the moment of greatest need and has just launched an expansion into the office sector with solutions that are already being used by large corporate and government owners. The program is partnered with numerous utilities that are capturing data from pilot installations to support a fundamental shift in program design towards incentives for kWh-based integrated solutions. The paper will provide examples of the newly released solutions for offices, and will describe how the webtool delivers best practices, measurement and documentation. Final outputs from the webtool achieve the dual goals of documenting owner progress against their energy savings goals as well as information for utility incentive submittals. New program directions will be detailed including a focus on implementation, training, user support and continuous improvement. The partnership model and its importance in the overall success of the program will be emphasized.

## Integrated Best Practices Lighting Solutions

Historically, the energy efficiency community has been primarily focused on technology opportunities in lighting. Component based programs have effectively harnessed what is often called "low hanging fruit," represented in lighting as lamps and ballasts. As those opportunities decline the energy efficiency community must focus its sights on program opportunities that maximize savings across all aspects of the opportunity spectrum. Figure 1 shows how lighting efficiency opportunities extend well beyond lamps and ballasts (in bold font) to include luminaires, lighting controls, design expertise, and given conditions. The Commercial Lighting Solutions (CLS) cover most of this spectrum, stopping short of influencing given conditions such as reflectances, space geometry, and workstation height. This comprehensive approach to harnessing *all* of the energy efficiency tactics *while also* delivering lighting quality in keeping with the Illuminating Engineering Society (IES) standards is the basis of the best practices.

**Figure 1. Lighting Efficiency Opportunities**




## Next Generation Commercial Programs

The Commercial Lighting Solutions have been developed by the US Department of Energy as a means to support the next generation of commercial programs, which—due to their very nature—are extraordinarily complex. The goal is to do the appropriate and complex analysis on the development side, but deliver a product that is easy to use and understand. All of the energy efficiency factors illustrated in Figure 1 have been developed into a series of prescriptive offerings with accompanying energy savings estimates as a means to provide a flexible platform for national use by utility and energy efficiency programs. It would be fiscally unfeasible and also unwise to develop such tools at a local or regional level. Rather, local and regional entities can apply a variety of incentives and program approaches based on the backbone, structure and energy analysis engine within this nationally developed, free and publicly available set of tools.

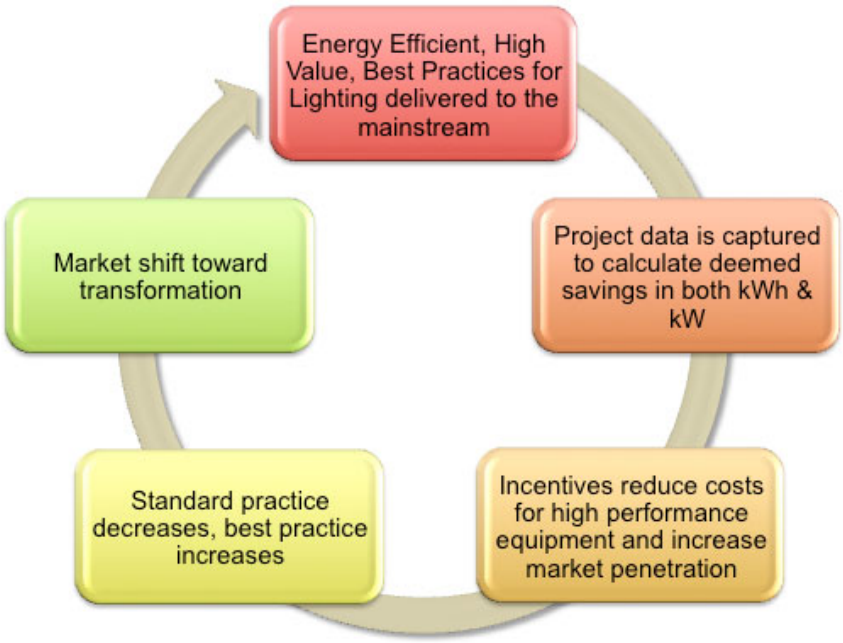
### Market Transformation Strategy

The causal logic showing how the Commercial Lighting Solutions program has the potential to create a long-term market transformation is illustrated in Figure 2. Energy efficient lighting best practices are developed and delivered to the mainstream for use by design teams to improve project designs. Once projects are developed into construction documents, the details of the final design can be captured in the webtool Energy Estimator, which will calculate energy savings in both kWh and kW. The output of the Energy Estimator provides the necessary information to make applications to various energy efficiency program incentives and rebates, which will increase the market penetration of high performance lighting equipment. The usage of the webtool by these programs will take time to establish, due to the variety of rates structures and diversity of assumptions used for establishing deemed savings. Groundwork has been laid in

the northeast towards a regional approach to using the webtool as a basis for deemed savings, but the process of developing this integrated approach will involve education, transparency, negotiation and consensus building. After the northeast, the next most likely progress is expected in the northwest and California. DOE is working closely with regional market transformation groups such as the Northeast Energy Efficiency Partnerships and the Northwest Energy Efficiency Alliance to facilitate this evolution towards incentivizing integrated lighting systems using the kWh metric.

Over time the availability of the recommendations in the webtool and the market pull dynamic of the incentives will increase the uptake of best practices, while also improving the skill sets of the lighting specifiers. Shifting the market away from the status quo towards best practices is a tall order, and will not happen overnight. The expectation is that progress will happen most quickly in the areas where energy costs are high and where progressive utility programs can support the change. Because the lighting solutions offer a visible and tangible improvement to the built environment, the hope is that increased penetration of best practices will also change expectations of real estate owners and tenants, garnering additional traction in the market towards transformation.

**Figure 2. Causal Diagram, Market Transformation Strategy**




## Consider the Audiences

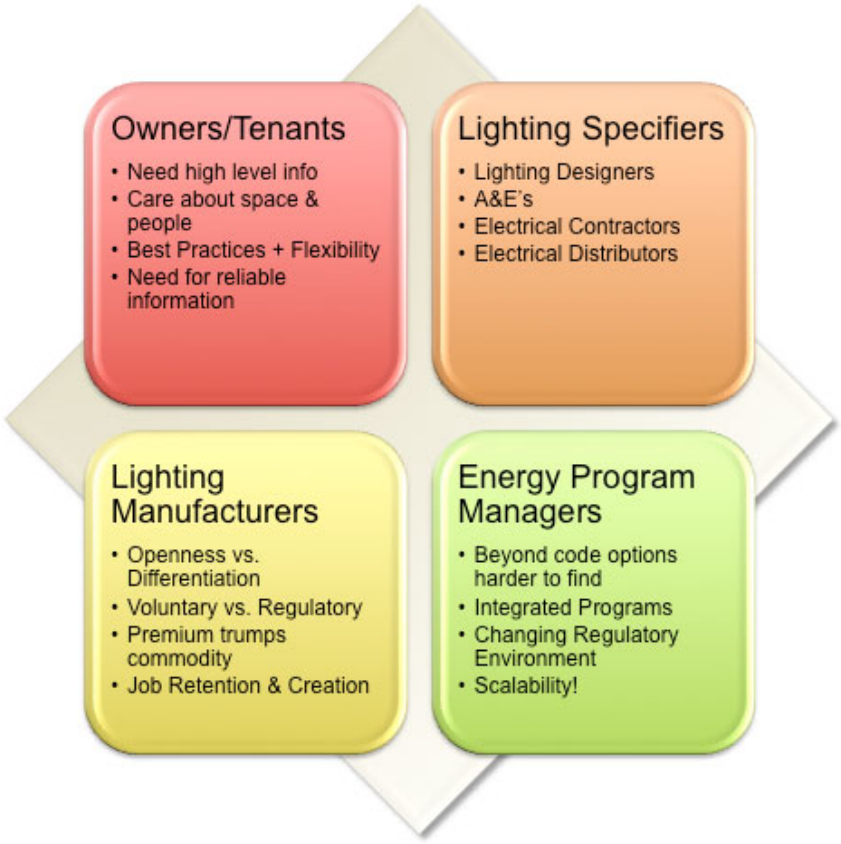
Many market actors are involved in creating lasting change, so the tools and solutions must not only be technically sound, they must also be geared toward the different levels of awareness and concerns of each of these audiences. Figure 3 shows the variety of players that must be met where they live for strategy to be effective. CLS has carefully considered these audiences during both the technical development process and in the design of the webtool and guidance documentation.

For example, the webtool user interface is simple, accessible, flexible, and graphically pleasing. It is designed knowing that non-experts such as owners and tenants will be walking through the tool and cannot be overwhelmed with too much technical information. However, at will, a user can hit various tabs and links to gather more information. Importantly, the download packets are stratified towards specific audiences. The Summary information is geared towards owners and tenants, but the implementation guidance is highly technical in nature and is geared toward the design team who will be executing the projects. The implementation guidance provides information about modeling assumptions, layout and spacing dimensions, installation, commissioning and maintenance guidance.

The webtool does not endeavor to replace or compete with lighting design calculation tools such as AGI32 or Radiance. Its purpose is primarily to provide best practice examples as a starting point from which modifications can be made at less cost and complexity, and to estimate the energy savings as various options are selected by the user. It offers a series of prescriptive approaches for typical spaces, as a way to get widespread application.

Following the launch of v2.0 in May 2010, the CLS team will be holding focus groups and developing targeted trainings to support the use of the webtool. Feedback is expected from the various audiences to support the continuous improvement process.

**Figure 3. Audiences and Partnerships**




**Partnerships and Alliances**

Each of the audiences shown in Figure 2 also represents a partnership opportunity. The USDOE has committed to a strategy that is partnership-oriented and comprehensive, working with all the players to provide integrated best practice lighting solutions for commercial buildings.

To achieve the aggressive energy efficiency goals, DOE is actively partnering with key building industry professionals who have the capacity to substantially influence improvements in commercial building performance. To this end, DOE has established the Commercial Buildings Energy Alliances (CBEA) and the Commercial Building Partnerships (CBP's). [DOE1] These alliances and partnerships create a structural and powerful relationship with large owners and tenants. The potential for influence is significant because the partner companies typically manage large building portfolios and often design, build, own, manage, and/or operate their own facilities allowing them to replicate lessons learned from specific projects.

Currently DOE hosts three industry-led alliances each with membership representing substantial proportions of the square footage in their respective sectors: the Retailer Energy Alliance (18%) [DOE2], the Commercial Real Estate Energy Alliance (23%) [DOE3], and the Hospital Energy Alliance (17%) [DOE4]. The alliances are informal associations of commercial building owners and operators who want to reduce the energy consumption, greenhouse gas emissions, and operating expenses of their buildings. Alliances are also planned for the higher education and government sectors as each represents significant energy use and opportunities for

efficiency. [ACEEE1] Alliance activities specific to CLS have included attendance at CLS roundtable meetings to provide input into the development of the Lighting Solutions and participation in CLS pilot programs.

Lighting specifiers, manufacturers and other buildings industry groups have been heavily engaged with the CLS team throughout the development and rollout phases to ensure transparency and wide buy-in. Charrettes have been held to gather input at the beginning of the conceptual design process for each of the market sectors. For example, these gatherings have included representatives from the National Electrical Manufacturers Association (NEMA), the International Association of Lighting Designers (IALD), the Lighting Controls Association (LCA), Building Owners and Managers Association (BOMA), American Institute of Architects (AIA), and more.

CLS has worked with energy program managers at individual utilities as well as regional and national organizations, including but not limited to: the Northeast Energy Efficiency Partnerships (NEEP), National Grid, Efficiency Vermont, NStar, New York State Energy Research and Development Authority (NYSERDA), Southern California Edison (SCE), Pacific Gas and Electric (PG&E), Consortium for Energy Efficiency (CEE), and more. Interaction with these groups has guided the development of the tool, especially with respect to the method of capturing savings for actual projects while expanding the metric to kWh.

These same organizations have provided extensive peer review input during the beta testing of each of the webtool rollouts, and the results have been published. [DOE5]

## Potential for Impact

In its third year, the program is maturing at exactly the moment of greatest need, providing CLS with potential for significant market impact. Several opportunities for measurable impact are worth noting.

- **Application to existing building stock.** Importantly, the solutions within CLS can be applied to existing buildings as well as new construction. The solutions do not currently endeavor to provide simple component retrofit solutions for existing buildings, rather, they provide relighting (or redesign) opportunities suitable for tenant fitout, modernizations, or owner occupied renovations. The solutions include new fixtures and controls, which provides far more savings that can be achieved with simple retrofits. The goal of CLS is to go beyond the lamp and ballast change out mentality, and pursue much deeper energy savings in our existing building stock. Many of the professionals that are responsible for lighting are not lighting experts, and need explicit guidance about energy efficient relighting approaches. CLS does not offer customized approaches for every space, but it does offer useful templates for typical spaces and conditions, and will serve as a starting point for those professionals who otherwise may not consider using new fixtures and controls.

- **GSA ARRA relighting.** The lighting solutions for offices were in the development process just as the ARRA legislation was being developed and passed. By virtue of the GSA and DOE partnership on the Commercial Real Estate Energy Alliance, the CLS team developed a series of detailed specifications and scope of work input based on the office lighting solutions. These specifications represented a significant commitment on

the part of GSA to take maximum advantage of the Recovery Act to pursue deep energy efficiency and infrastructure upgrades to Federal Buildings by using best practices. The guidance documents were released to all of the GSA regions in June of 2009. While not every project will have used the lighting solutions within the relighting specifications, there has been very significant uptake. Given the GSA's Recovery Act budget of $4.5 billion for new and partial modernizations (of which lighting represents only a portion), the use of the CLS guidance arguably represents one of the largest applications of lighting best practices.

- **LEED compliance.** Currently, more than 30 states, 35 counties, and 130 cities reference LEED in policies, ordinances, and incentives. Most of these have requirements that public construction be LEED certified or receive a certain LEED level (i.e. gold, silver). To achieve the LEED certification, energy must be reduced below the ASHRAE 90.1-2004 benchmark. The architect tasked with designing the lighting system to achieve this goal can find himself/herself in design territory with large risks. The CLS tool can provide a valuable way for designers, who don't live and breathe lighting, to meet their LEED goals.

- **Office of the future / advanced energy office.** Almost from its inception, the CLS program has been partnered with the Office of the Future Consortium (formerly known as oPod). This group includes the large majority of the most progressive utilities, and it's focus is to create a series of packaged and integrated energy conservation measures for office tenant spaces, for all of the building energy systems including plug load. AEO has used the Commercial Lighting Solutions as the primary basis for it's lighting packages, and is very actively installing 8-12 commercial office pilot projects in 2010 in the various member territories. The explicit purpose of the AEO pilot program is to demonstrate the savings of their packaged technical solutions, and gather metered data to use for developing deemed savings for the various ratepayers groups and utility regulators. Empirical data from these projects will be fed into the CLS webtool as a means to create continuous improvement of the controls savings estimates.

## CLS Webtool

The CLS Webtool is the delivery mechanism for a series of best practice lighting design solutions that provide "how-to" guidance on achieving deep energy savings as well as the means to capture energy savings estimate for actual projects. The webtool format is integral to the value of the lighting solutions because of the following features:

- The interactive format allows for a more meaningful introduction of pattern tools without overwhelming the user, because the friendly workflow allows selection from numerous options rather than a smaller number of overly generalized concepts.
- User selection of preferred designs provides immediate feedback on the energy consequences.
- The format offers a visual element (perspectives, graphics, layout) that is more impactful than one typical finds in a static document, thereby keeping the user engaged.

- The electronic format delivers a wealth of information inexpensively including performance specifications, making the solutions more actionable and less theoretical than static formats.

**Best Practices**

The guidance is comprised of integrated Lighting Solutions that include high performance products, expert electric design and daylight harvesting, lighting controls, and installation and commissioning guidance. The accessibility and dynamic nature of the webtool helps to bridge the gap between the traditional design guides and high volume implementation.

Lighting solutions for retail applications have been available since LIGHTFAIR International 2009, and were discussed in detail in previous papers. The newly released set of solutions in the Version 2.0 of the webtool are for office buildings, and will be the basis for most of the examples in this paper. Several new and innovative features have been integrated into the user interface and will also be discussed.

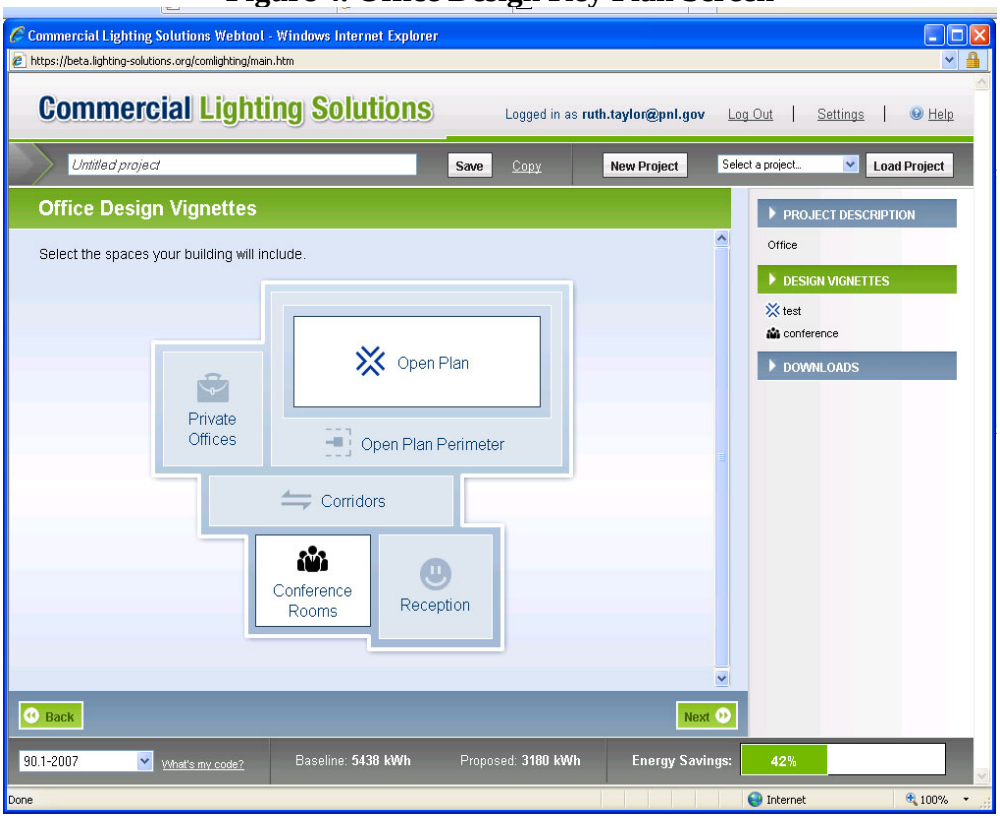
The Lighting Solutions that are available in the webtool are optimized for energy efficiency, cost effectiveness, and occupant satisfaction. They are made up of two distinct pieces—the first is the lighting design, or Lighting Vignette, which encompasses the equipment used in the lighting layout. Each vignette provides detailed information on luminaire mounting height, spacing, and maintenance issues associated with the lighting system. Reputable lighting design firms with extensive expertise in both energy efficiency and lighting quality developed the vignettes, which were based on IESNA lighting criteria. The designs were modeled using industry standard point-by-point lighting calculations. Vignette solutions include numerous design options including recessed high performance lensed troffers, direct/indirect suspended pendants in continuous rows, and digital workstation-specific direct/indirect pendants with personal control.

The second major component of the lighting solutions is lighting controls, or Controls Templates. These solutions are groups of control strategies that optimize energy savings for specific space types. Users can choose their Controls Template from a pre-populated list based on the selected, space-specific Lighting Vignette. The Controls Templates were developed with input from lighting controls manufacturers and the Lighting Controls Association.

The webtool provides real-time saving assumptions based on the user's building type, location, hours of operation, and baseline energy code. The selections are stored in the tool's database as the user-specified baseline, against which all energy savings are compared.

Office buildings were divided into different space types based on the function of each space. The webtool offers integrated Lighting Solutions for (1) open plan offices (2) perimeter solutions for open plan offices, (3) private offices, (4) meeting/conference rooms, (5) reception spaces, and (6) corridors. The Lighting Solutions vary in both the lighting design and controls templates as the visual needs and characteristic activities and use patterns of the spaces vary.

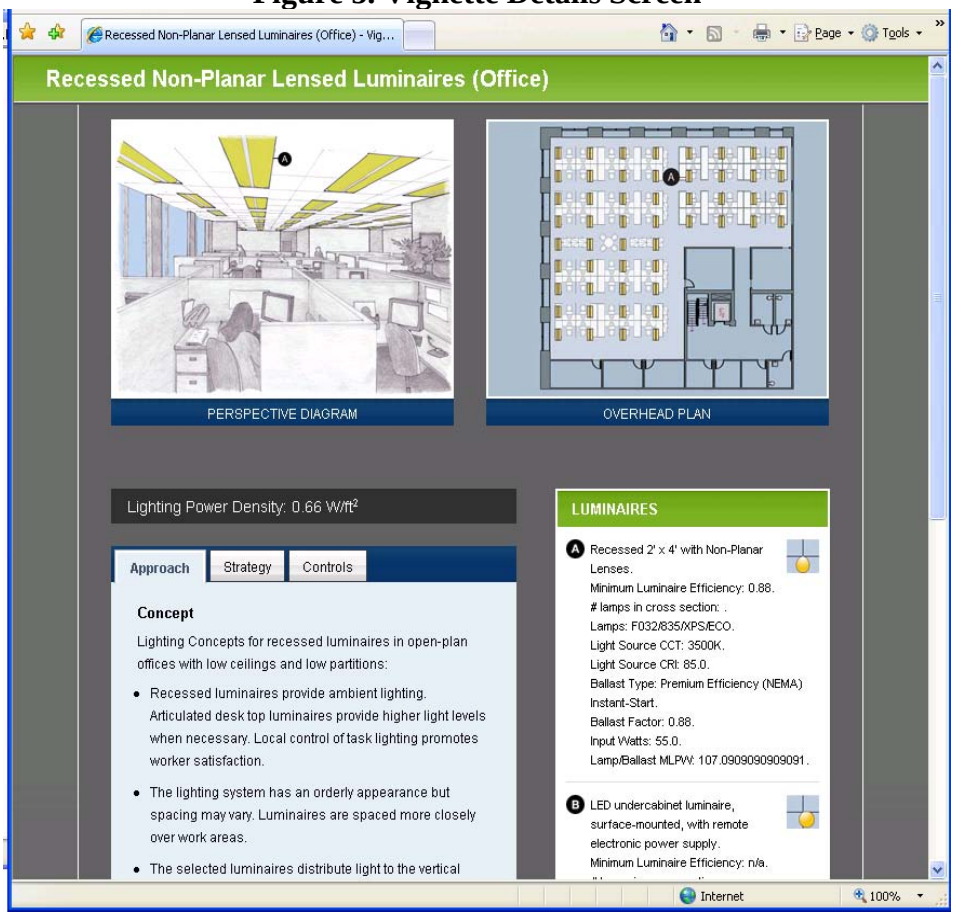
**Figure 4. Office Design Key Plan Screen**




There are many variables that occur in the office space types that drive lighting design. These include corridor width, partition height, workstation density, ceiling height, and area of the space. The webtool requires that users identify these important space type characteristics before offering any vignette options. The list of vignette choices will vary depending on the characteristics of the space. For example, a direct/indirect lighting solution would not be applied to a space with 8' ceilings.

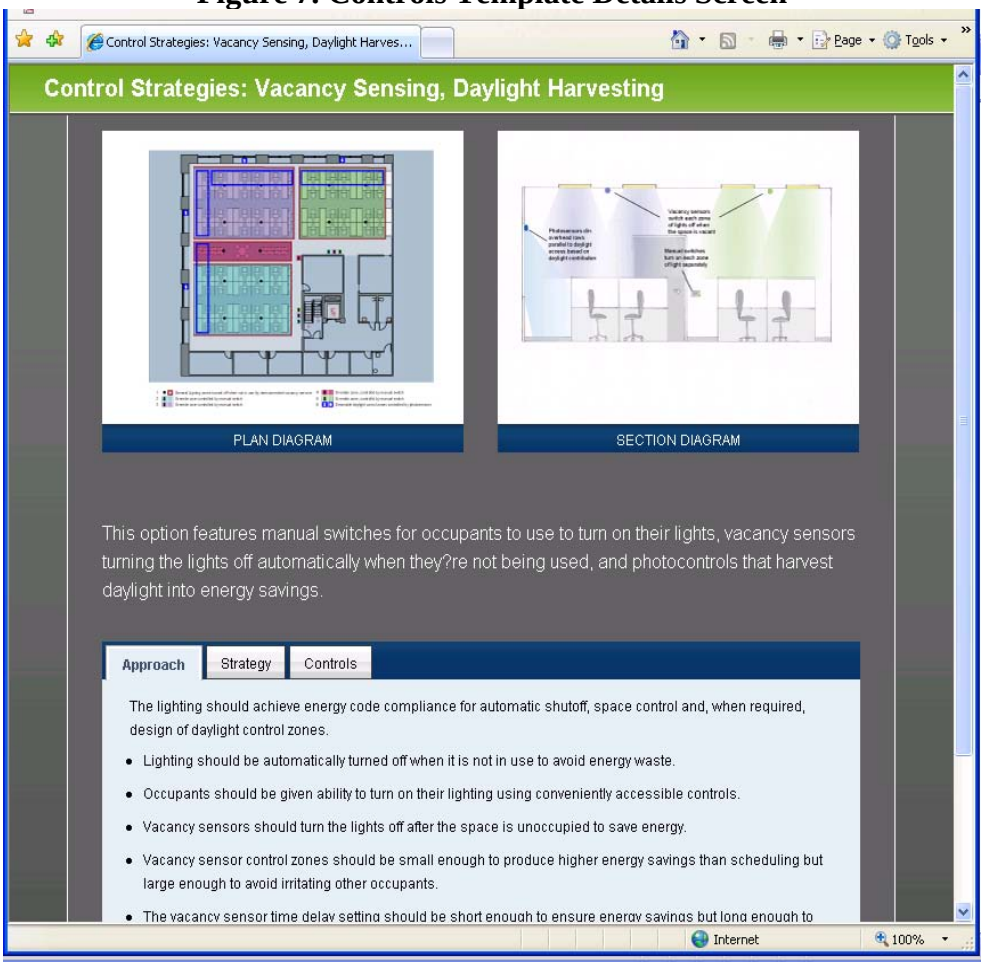
Once the appropriate information has been provided, the user is presented with a list of 2-5 applicable lighting design options. The text is basic enough to ensure that owners and a non-technical audience will be able to compare the vignettes and provide input during the conceptual phases of the design process. There are also plan views and perspective images that help both the technical and non-technical audience understand the design of the lighting system and how it will appear aesthetically in the space.

**Figure 5. Vignette Details Screen**




After the lighting layout decision is made, the controls templates are outlined in a similar format to allow any range of users to understand what the controls systems mean, and what they are meant to achieve. Controls templates are offered based on the user input regarding the parameters of the space (e.g., daylight dimming solutions would not be offered if the space does not have available daylight). The controls templates are designed specifically to exploit the range of flexibility that would be desired in the various spaces. For example, in open plan offices, controls templates offer options ranging from simple to complex such as (a) basic automatic shut-off with zoning, (b) automatic shut-off with vacancy sensing and daylighting, or (c) digital control systems that provide maximum dimming flexibility and occupancy sensing for each workstation in addition to daylight harvesting.

**Figure 7. Controls Template Details Screen**




The tool also allows users to define the same space type more than once. This feature is particularly beneficial, for example, when a building owner wants to differentiate the large executive offices from smaller offices meant for junior staff members.

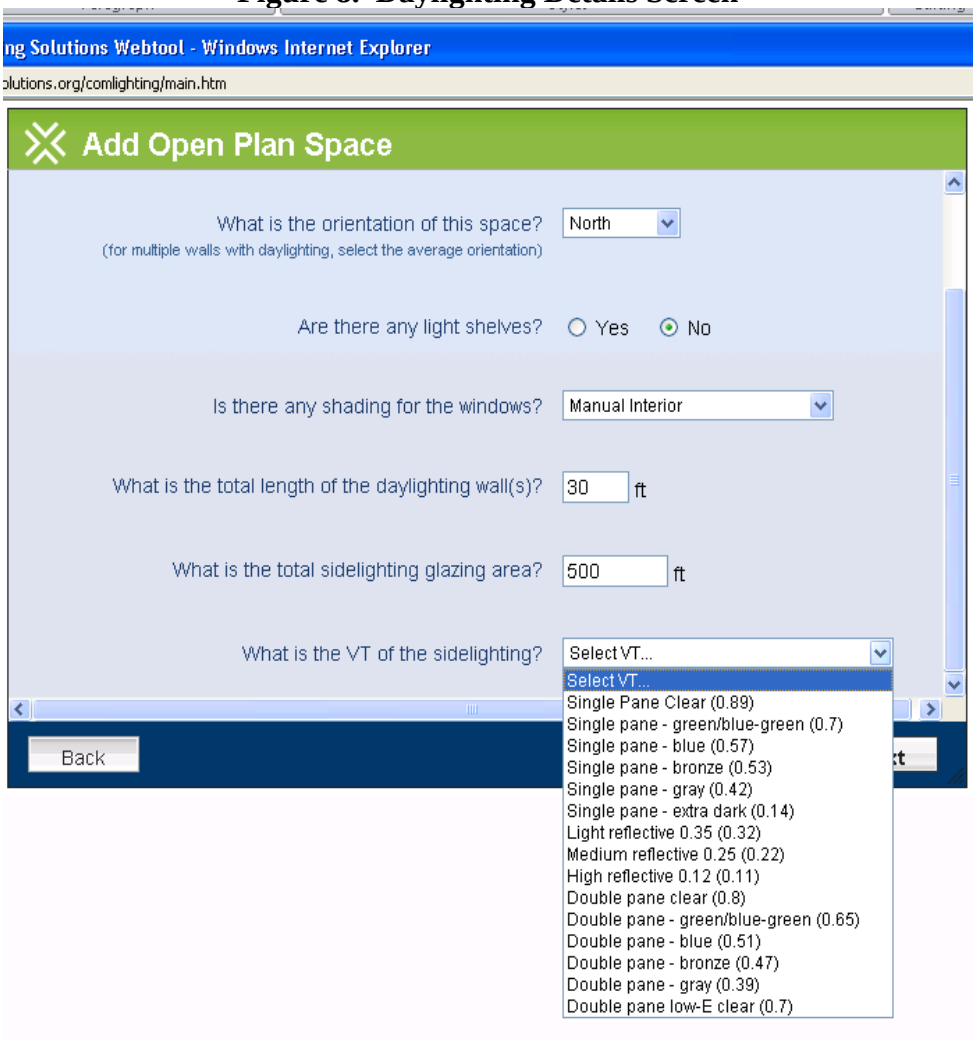
The process for calculating energy savings is largely focused around energy use in kilowatt-hours (kWh). Each vignette has an associated lighting power density (LPD), which is then multiplied against the user-provided area. This product represents the kilowatt total (kW), which then becomes the basis against which controls savings are applied. Energy savings is calculated against the user-chosen baseline for both kW and kWh. [ACEEE2] For example, energy codes that require occupancy sensors would not gain any savings for choosing a controls template that specifies an occupancy sensor, where the same template applied to a code that does not require any lighting controls above whole-building shut-off would realize the full savings associated with the application of the control.

All of the savings are captured in a database within the webtool and the assumptions are made available to interest users, utility commissions and energy programs. A planned enhancement is to create a web-based relationship between the codes compliance software ComCheckEZ and the CLS webtool so that files may be transferred between the web applications.

Daylighting is an integral part of a highly successful energy-efficient lighting system. In office buildings, daylighting comes primarily from sidelighting. The variability of sidelighting in

turn causes a broad range of savings associated with daylight harvesting. Building orientation, fenestration area, and visible transmittance of the glazing are a few of the major factors that drive the degree of energy savings that are possible.

**Figure 8. Daylighting Details Screen**



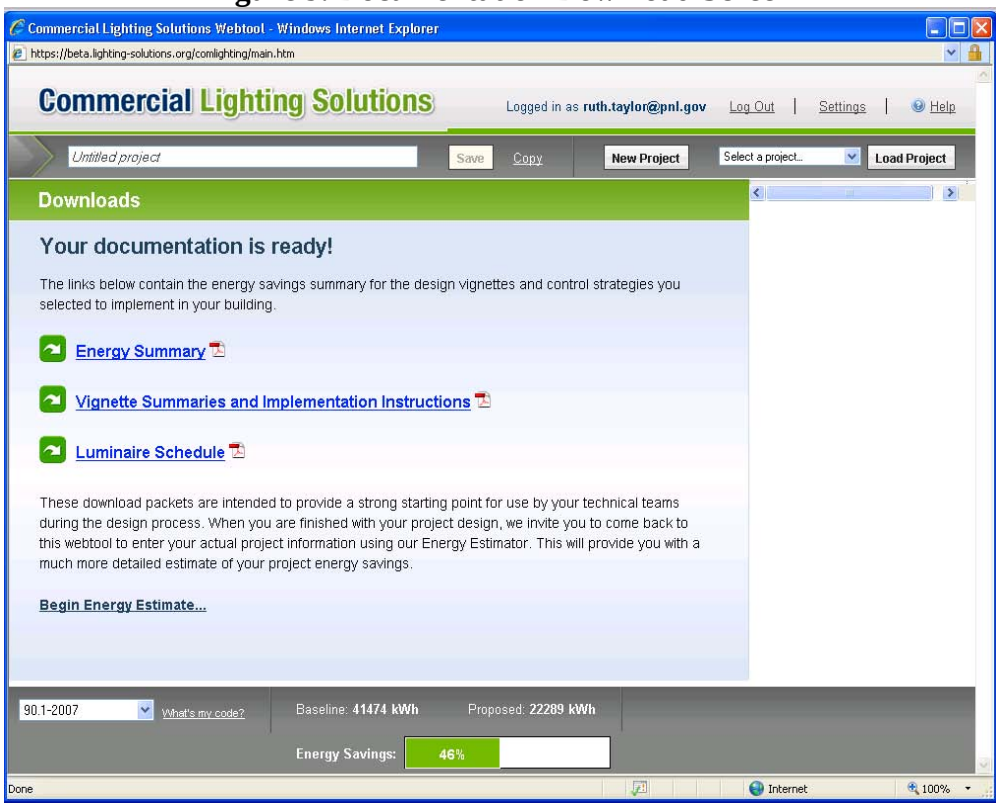

Providing users an accurate estimate of their potential energy savings is instrumental in helping them make informed decisions. This is why users are required to to provide the daylighting characteristics of each space type where applicable. The length of the window wall, the area of the glazing, and the ceiling height are used to calculate the window to wall ratio (WWR). The specified visible transmittance (VT) is then applied to determine what the effective aperture is associated with the space.

The savings assumptions that are applied to daylighted spaces come directly from applicable research where real building energy data was monitored for various buildings in multiple climate zones. The savings associated with the actual buildings are then sorted based on the orientation of the space and the choice of shading devices. In this way the tool is able to represent the potential energy savings of a space with a daylight harvesting system, based on the most relevant variables.

## Delivery of Best Practices

For a design to be actionable, it not only needs to integrate all the elements of the lighting system into a lighting layout with efficient equipment and control recommendations as discussed above, but it must also have application, installation, commissioning, maintenance and operations information. For this reason, a series of automatically generated downloads containing this information are available after lighting solutions have been designated for all of the applicable space types. The Summary and Implementation download summarizes the chosen lighting solutions with information that supports execution, the Energy Summary outlines the anticipated energy savings associated with the decisions made as compared to the baseline code defined, and the Luminaire Schedule outlines all of the lighting equipment used in the vignettes.

**Figure 9. Documentation Download Screen**

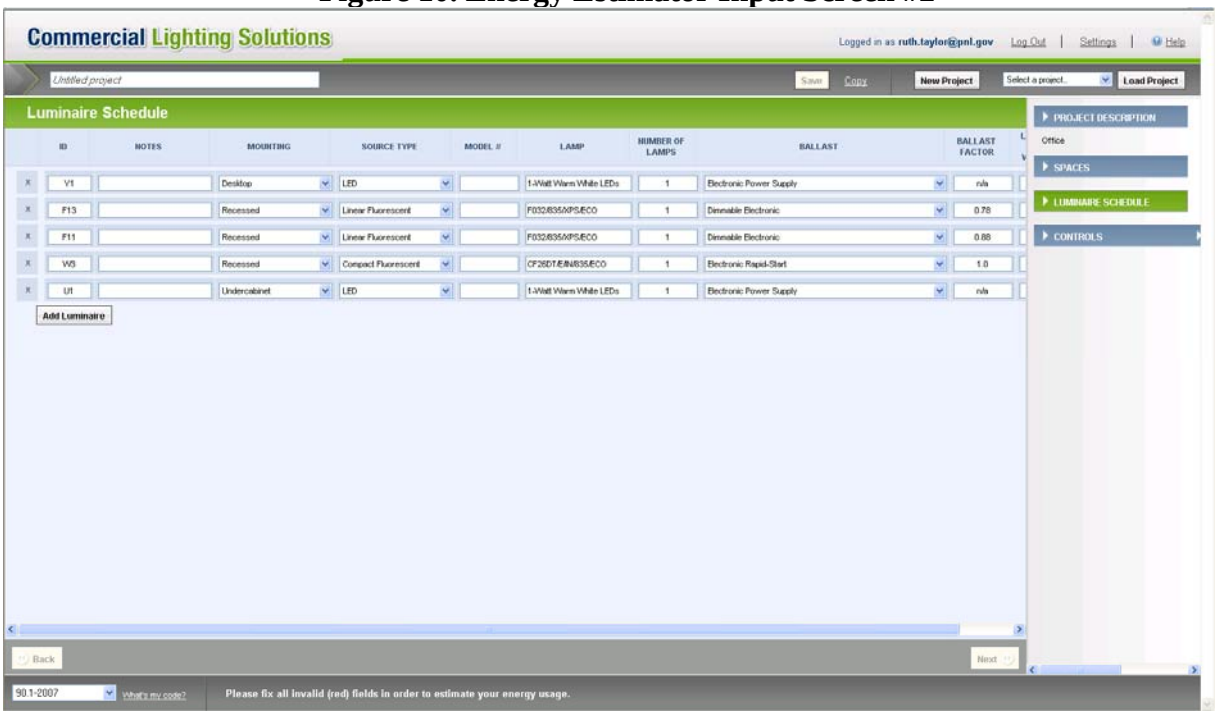



The program is designed to provide actionable, detailed performance specifications to design high efficiency spaces. The information provided on the webtool is geared toward a general audience, and supports the conceptual design phase. The implementation instructions that are provided in the download are much more technical in nature, since it should be a professional lighting designer, architect, or engineer that adapts the lighting solutions to fit the requirements and parameters of individual projects. It is understood and articulated that the best practices offered to the user represent a starting point to enhance the design options for the design team; the design process is supported, not controlled, by providing this guidance.

## Tracking of Actual Projects

One of the most substantial additions to the webtool v2.0 is the Energy Estimator. This new feature is generally not accessed until after the lighting solutions have been selected and the best practice ideas have been applied to the project with the appropriate real-world adjustments and revisions. It is at this point in the building process that the program gathers actual project data from the user to better understand how the lighting solutions are adapted to specific applications. The tool also provides users a place to track the equipment used on their project, facilitating a more accurate estimate of energy use based on this equipment.

**Figure 10. Energy Estimator Input Screen #2**




After the user project data is collected, another download is made available to the user. The *Energy Estimator* download provides a detailed summary of all of the equipment used on the project along with a precise reduction in power usage that is associated with that equipment. In this phase, the anticipated controls savings are applied in a more meaningful way, since the reduction is only applied to the luminaires that are wired to be a part of the controls system. All of this information is outlined in a format that utilities and other Energy Efficiency Program Sponsors (EEPS) can readily understand while issuing appropriate rewards for their incentive-based programs. The Energy Estimate report includes a list of equipment and quantities, space-by-space energy estimates for baseline and proposed conditions for both kW and kWh, savings attributed to luminaires vs. controls, the luminaire schedule, and an equipment installation list to support walkthroughs and inspections.

## Implementation

Release of the CLS webtool does not guarantee its use. Successful implementation of the Lighting Solutions will require significant interaction with other lighting and energy efficiency domain experts and market delivery channel masters. Mechanisms to encourage this interaction will involve pilot projects and various types of targeted training to support the use of the tool.

- **Training.** Initially, cost effective web-based orientation training was developed as a means to educate users. Next, in-person training was developed in a modular format to support use by both EEPS and end users. A particular area of focus has been training on the specification, installation and commissioning of intelligent workstation-specific intelligent lighting solutions for offices. The strategy is to eventually deliver trainings through partner organizations with train-the-trainer programs or by leveraging existing training venues and portals.

- **Pilot projects.** Pilot projects demonstrate the value of the Lighting Solutions and are selected based on the strategic value of the project, its applicability to the market sector, and value to partners. Technical support for the pilot projects includes education and training about the Lighting Solutions with end users and their design teams. Pilot project owners and tenants will ideally partner with utility and energy efficiency market transformation stakeholders to utilize incentives to buy-down the higher costs of the more efficient equipment, and to get their support for energy consumption measurement of installations. Measuring the actual energy performance of the projects will be critical to each pilot project's success.

- **User support.** Direct user support to Alliance members and their design teams is another important part of the CLS tool's implementation. Particularly valuable insights will be gained by gathering user feedback on the use of the energy estimator. Since the estimator gathers actual project data it captures the degree to which end users incorporate the best practice solutions into project designs. Insights into this process are extremely valuable for the tool's development and ultimately increased energy savings. One mechanism for gathering this feedback will include an in-person approach with hands on exercises using specific project examples. Recipients of this training are strategically chosen; alliance members with the highest likelihood of making near term impact with CLS designs will be the priority.

- **Continuous improvement.** Feedback from trainings, pilot projects and user support tasks will all feed into continuous improvement of the webtool and the CLS program. Next steps include adding lighting solutions for hospitals, higher education and government buildings. Feedback from users about the webtool gathered from peer review and usage is continually analyzed, prioritized, and acted upon as resources become available. Future tasks are likely to include the addition of case studies to the website, an interface to manufacturer products, an online automated user satisfaction survey (for offices), and generic CSI formatted specifications for selected solutions.

## Conclusion

In summary, the Commercial Lighting Solutions program represents an evolution that will result in a sustained market shift towards energy efficient best practices for lighting. While the offerings are prescriptive, the fact that there is a continuous spectrum of integrated options makes the tool more like "how-to" support for a performance-based approach. Considering the quantity of design options along with the inclusion of controls and the use of the kWh metric, CLS is effectively a hybrid between performance and prescriptive based programs. The holistic approach including an understanding of the needs of the various audiences and market players, strategic partnerships, technical robustness and transparency, scalability via the webtool, and the resulting data stream as users capture their savings online will contribute meaningfully to the overarching movement towards integrated sustainable design across all the building systems.

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