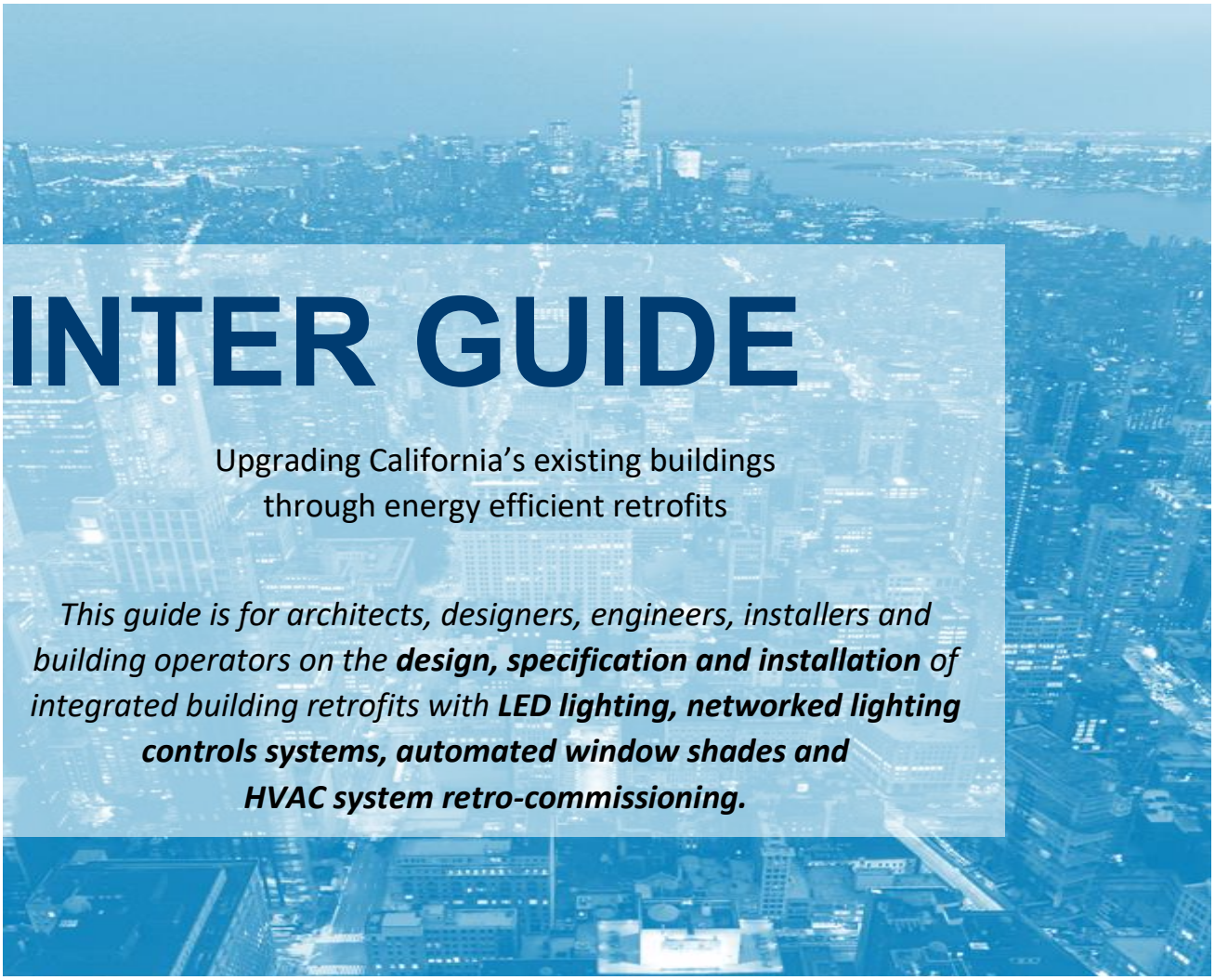

INTER GUIDE

Upgrading California's existing buildings
through energy efficient retrofits

This guide is for architects, designers, engineers, installers and building operators on the ***design, specification and installation*** *of integrated building retrofits with* ***LED lighting, networked lighting controls systems, automated window shades and HVAC system retro-commissioning.***

A product of the Leading in Los Angeles demonstration project funded by the California Energy Commission and Southern California Edison

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1 Introduction

1.1 About this Guide

This guide enables architects, designers, engineers, installers and building operators to maximize the many benefits of the INTER Technology Solution, integrating networked lighting controls (NLC) systems and automated window shades retrofits with HVAC system retro-commissioning.

The guide will introduce the benefits of integrating LED lighting with networked lighting controls (NLC), automated shades, and HVAC retro-commissioning; define project roles and considerations; provide guidance for design, specification, and installation of these integrated retrofits; and resources for building occupants and operators to better understand these new systems.

1.2 About the INTER Technology Solution

The Leading in Los Angeles (LiLA) research project is a California Energy Commission-funded effort in response to the critical need to greatly reduce energy use in the state's existing commercial buildings with cost-effective and scalable solutions, particularly in the Los Angeles Basin where energy constraints from the Aliso Canyon fuel leak are acute.

Launched in June 2017, the project efforts include a four-year combination of lab test, field demonstrations at two office sites, and developing market connection efforts to move an integrated set of emerging commercial retrofit technologies into wider adoption.

The project focuses on deployment of the INTER Technology Solution, which combines an innovative set of technologies targeted across window shades, lighting and HVAC as shown in Figure 1. These end uses make up most a building's energy use (approximately 70% for a typical office).

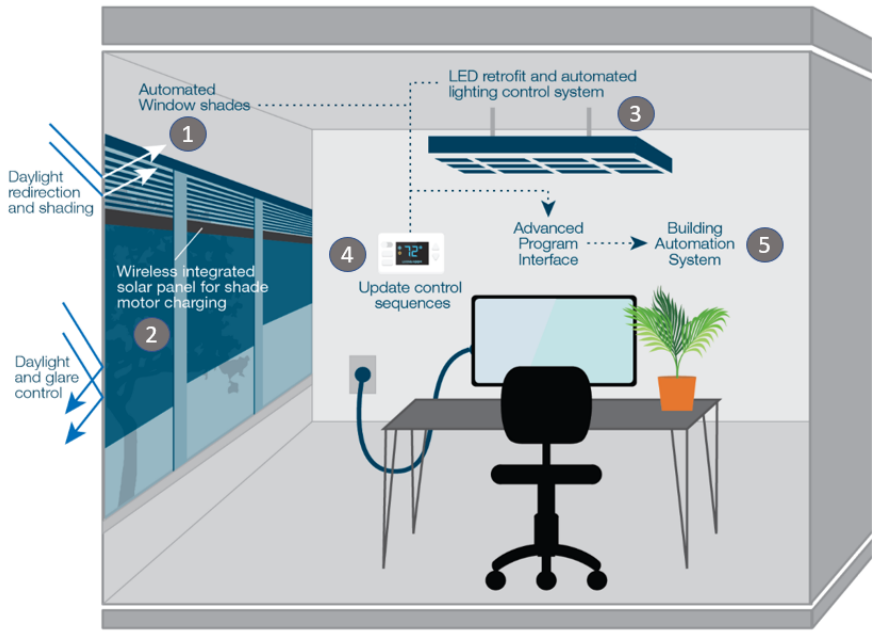


Figure 1: INTER Technology Package

The technology package integrates the five efficiency improvements illustrated in Figure 1:

1. Automated wireless (solar powered) interior shades with an upper redirecting louver portion
2. Wireless solar-powered batteries supply the motors at each shade
3. Advanced lighting control system (ALCS); renamed to networked lighting control (NLC) to match the current industry terminology. When controlled at the individual fixture these are called Luminaire-level lighting control (LLLC) systems
4. Light retro-commissioning (RCx) of the Heating Ventilation and Air-conditioning (HVAC) system
5. Measurement and Verification (M&V) 2.0 procedures for performance validation with advanced sub-meters tied together with central controls

The technologies can be combined and customized to suit a variety of building types and spaces resulting in an estimated whole building energy reduction of more than 20%. Market attraction will be improved occupant control and comfort, reduced transaction costs, and ease of installation. The project has two fundamental goals:

- Validate the commercial viability and scalability of INTER systems in existing commercial buildings
- Accelerate market adoption of INTER system approaches to address Los Angeles basin and statewide needs for energy and carbon reductions through deep energy efficiency retrofits

Shades are often considered an aesthetic upgrade in a building by owners and occupants, so the potential energy savings is only a part of an occupant comfort and enjoyment improvement that goes beyond the energy benefits of an automated shading system, thus shades are not normally considered for energy efficiency programs. An integrated approach like the INTER system allows the energy benefits of shades to be leveraged through the responsive controls inherent in an NLC and dimming-capable LED lighting system, and further by a responsive HVAC system.

1.2.1 Benefits of INTER

The combined measures of the INTER system package are designed to provide synergistic benefits greater than the sum of the benefits of each measure individually. Benefits from the INTER system include energy, operational, and amenity benefits.

Energy benefits from the INTER system leverage the interactive and synergistic benefits of the combined measures. For example, the daylight redirecting portion of the window shades enables the daylighting controls to reduce energy use even during conditions when the view portion of the shades need to be closed to prevent glare, excess heat gain, or to provide privacy. In addition, the sensors included as part of the NLC can be integrated with HVAC retro-commissioning control sequences to provide occupancy-based HVAC control where system zoning allows.

Real-world examples of the savings at Los Angeles area buildings – one being a university administrative office building with some lecture and classroom facilities and the other a city-owned office building – show substantial lighting and whole building (Site) energy reductions following the installation of the INTER solution set.

Location	Site Energy	Lighting Energy
CSUDH Welch Hall	26%	35%
Santa Ana City Hall	15%[1]	42%

[1] Steam energy data was not available so whole building energy savings may be larger

Figure 2: Measured Energy Savings of INTER System retrofits in two field demonstration sites, compared to pre-retrofit energy use

Operational benefits of the INTER system technologies include the potential for future improvements and flexibility. By implementing the communication network infrastructure and networked devices ("internet of things", or IoT), building systems can be more easily upgraded when new software becomes available, and systems and controls protocols can be adjusted to accommodate building reconfigurations or changes in use, especially during tenant turnover. Upgrading to LEDs reduces lamp change out frequency and the shades often reduce tenant complaints of thermal or visual discomfort – both powerful benefits to owners and operators.

Amenity benefits from the INTER system package include the aesthetic improvement of new shades systems, as well as improved access to views and daylight through the automated shades that open to views when conditions permit, and automatically close to prevent glare when needed. The highly configurable lighting system also allows for fine tuning and customization of lighting levels, down to the fixture level in some cases.

More broadly, the INTER system benefits from a "systems-approach" strategy. Recent research and development efforts, like the Leading in LA project, have produced measure *packages* that can take advantage of the individual measure savings but are also open to the opportunity for additional savings through the bundled approach. Some of the potential benefits of a package of measures include:

- A systems-approach promotes energy efficiency in a greater range of opportunities including the value of aligning the devices to be coincident where possible in time of use which can provide peak demand reduction benefits to the customer and utility.
- The systems-approach is likely more capable of future operational and efficiency enhancements due to the connected nature that incorporates and accommodates communication integration with other building systems.
- A systems-approach takes advantage of the overlap in work needed for installation and setup with other measures to reduce the costs of each individual measure, as well as mitigate the risk that repeated operational disruptions become a barrier to implementation.
- The systems-approach leverages the savings from high cost effectiveness measures to cover measures that are lower in cost effectiveness to produce higher total energy savings and amenities in the building.

1.2.2 Ideal Scenarios for INTER Systems

The INTER system is an ideal approach for office spaces that meet the following requirements:

- There is generous daylighting availability in the building spaces.
- The spaces benefit from daylighting that is not blocked or reduced by external shading (trees or other nearby buildings), dark window glazing tint, and substantial overhangs.
- There is a lighting system that is ready for an LED retrofit (or has been recently retrofitted and includes an NLC system, or more preferentially, an LLLC system.
- The implementation of an LLLC control system will provide the best and most responsive lighting control to reduce energy consumption when the conditions are suitable.
- There is an HVAC system with adequate zoning and the control system to reduce the airflow with the right conditions.

The automated shading system is intended to provide an improvement in the visual environment of the spaces in the building and are not designed to produce substantial energy savings compared to a building with manual shades. There are a number of reasons for this, but the main one is that the shades will reduce daylight penetration much of the time and this may result in slightly higher energy consumption than a building without the shading system (depending on the manual settings). However, the intent of this system is to provide high energy savings while still yielding the best possible visual environment for the occupants to perform their duties.

2 Roles and Responsibilities for the Project Team

Successful implementation of an INTER system retrofit requires careful coordination between multiple members of the project design and installation team. The following sections detail roles and responsibilities on the project team, including the need for a dedicated "Systems Integrator" role to coordinate the integration of the various systems.

2.1 Systems Integrators

The role of the systems integrator is to ensure that component systems of an INTER retrofit, including both hardware and communications systems, meet the performance specifications as established by the specifier and the client.

The systems integrator role for INTER retrofits is modelled on similar HVAC system integrator and "Master Systems Integrator" roles. As interconnected and communicating building systems proliferate, there will be an increasing need for systems integrator professionals. Depending on the scope of the project, and the expertise required, the systems integrator role could be performed by one of the team members described in the following sections. Regardless of who performs the role, the systems integrator scope and responsibilities should be defined and planned for at the outset of any INTER system retrofit project. Responsibilities of the systems integrator should include, at minimum:

- Coordinating and/or developing hardware and communication strategies as needed to integrate the INTER system components with existing IT infrastructure
- Coordinating final commissioning of the INTER systems to ensure all sequences of operations are functioning as intended in the design and specifications
- Ensuring both the lighting and shading control systems are tied into the BMS
- Ensuring the lighting system responds appropriately to the dynamic lighting conditions introduced by the shades
- Developing any operation manuals and training required for building maintenance and operations staff
- Ensuring building occupants are familiar with the new systems, to the extent applicable

2.2 Specifiers

Specifiers for an INTER system retrofit project may include architects, interior designers, lighting designers or electrical engineers, and mechanical engineers, and will typically involve multiple or all of these. The role of specifiers on an INTER retrofit is similar to a specifier role on other types of projects, though specifiers of the different component systems may need to collaborate more closely to ensure the interoperability of the systems.

Specifiers are responsible for establishing both the aesthetic and performance parameters of each of the individual systems. These parameters may include, but are not limited to:

- Material type and color of the shade fabric
- Design, performance, and placement of luminaires

- Type and location of lighting control sensors
- Control schema and sequence of operations for automated shades and lighting controls (and any HVAC controls sequencing or integration, where applicable)
- Control system communication requirements and capabilities

In addition to specifying the physical characteristics and performance attributes of the INTER systems, specifiers may also determine the parameters of any operations manuals, and the role of the systems integrator specific to a given project.

Specifiers may also have a role in confirming that their specified products or systems are properly installed and operational at the site, in collaboration with the Systems Integrator and the Installers.

2.3 Installers

Installers are responsible for delivering the INTER systems as defined by the specifiers. Primary installer responsibilities include:

- Installing products at the site as specified
- Ensuring products are properly set up and operational
- Coordinate with Systems Integrator to ensure effective communication between installed products and the control system
- Support final system commissioning, as defined by the Systems Integrator

Installers may also propose product solutions to meet the performance parameters established by the specifiers, if specific products are not already selected in the specification.

2.4 Product Support

Manufacturers or manufacturers' sales representatives should provide technical support for the individual systems in an INTER retrofit. This technical support should understand the system integration and communications aspects of their respective products, appropriate site characteristics for successful outcomes, and be able to provide any necessary installation and set up support. Product support may include, but is not limited to:

- Product information and technical specifications
- Design specification and installation guidance
- Product warranties and claims procedures

2.5 Building Operators and Facility Managers

Building Operators and Facility Managers (including IT professionals) are responsible for aiding the integration of the INTER systems retrofit into the existing building infrastructure and maintaining the systems over the life of the retrofit. For the remainder of this section, this group will be referred to collectively as “Operators”.

Operators are responsible for coordinating with specifiers, systems integrators, and installers to ensure that specified systems can be installed in the existing building. This includes informing specifiers and systems integrators about the details of existing building systems to ensure compatibility, or to determine if other system upgrades are required to support the INTER retrofit. Existing systems that may need to be compatible with the INTER retrofit systems include IT infrastructure, as well as any HVAC operations that will be included in the INTER upgrade.

Operators are responsible for understanding the operation of the INTER system overall and how to maintain the system and use it most effectively. Operators must also ensure that any regular maintenance items associated with the system are scheduled appropriately and are performed in an appropriate time sequence. This may include replacing or charging device batteries or keeping software up to date. These regular maintenance items are similar to a regular air filter replacement schedule on an HVAC system, and are equally critical to the long-term performance of the system.

Operators are also responsible for maintaining any operation manuals and disseminating any operation instructions to building occupants, as needed. Operators should also ensure that operation manuals are kept up to date with any hardware or software changes over the life of the system.

3 Design and Application Considerations

The following sections describe considerations for design, specification, and application for each of the component systems of an INTER retrofit. These include design and specifications issues specific to an INTER system approach, as well as consideration for suitable application types.

3.1 Shades

The automated window shades in an INTER system retrofit are active building systems intended to improve visual and thermal comfort and provide energy savings through reduced lighting and HVAC loads. As a result, implementing these shades requires additional considerations beyond the typical selection of window coverings. The accuracy of your specification and price to the owner, and the success of the contracting phase and installation, are highly dependent on having clear and comprehensive specifications. The considerations start as outlined below.

- ***What are appropriate applications for automated shades?***
  - Buildings with relatively high window-to-wall ratios are more likely to benefit from comfort and energy improvements. Similarly, buildings with relatively narrow floorplates may see greater benefit from automated window shades, where a larger proportion of the building has access to daylight, compared to buildings with deep floorplates.
  - Large, open-plan spaces and shared offices may be well suited to an automated shade system that automatically closes the shades to prevent visual and thermal discomfort when direct sunlight is present, and then automatically open the shade to provide views when glare is not a problem.
  - Buildings with external obstructions (such as trees or other nearby buildings) or architectural obstructions (such as overhangs, dark tinted windows, brise soleil, etc.) may receive minimal benefit from automated shading.
- ***What are appropriate applications for light-redirecting blinds?***
  - Buildings with windows on east, south, and west facing facades may benefit from light-redirecting blinds on the upper or “clerestory” portion of the window to provide daylight (and lighting energy savings) in the space even when the view portion of the shade is closed to prevent glare.
  - North-facing windows generally do not require light redirecting blinds as they are very rarely exposed to direct sunlight.
  - Windows must also be tall enough to accommodate the light-redirecting blinds without introducing additional glare sources or obstructing views out of the window. Ideally, windows with light-redirecting blinds should be able to accommodate an 18”-24” tall section of blinds with the blind portion of the shade starting at least seven feet above the floor. In other words, the top of the window must be at least 8’-6” to 9’ above the floor to accommodate light-redirecting blinds.

- ***What to consider when specifying automated shades:***
  - Consider how the shades will be powered. Many retrofit solutions will not have power available at the window frame and will require either a solar or battery powered solution for the shade motor. In applications with solar power, ensure sufficient solar availability to maintain operation of the shade. External or architectural obstructions may prevent sufficient solar charge to power the shades.
  - Consider the material of the shade. Opaque and translucent materials block views to the outside when closed. Perforated materials (typically 1% or 3% openness) can allow for views out even when the shade is closed, while still preventing excess glare and heat gain. However, excessive openness in perforated shades can result in excess heat gain and thermal discomfort.
  - Consider the color of the shade. Roller shades can often be specified with different colors on the inside and outside surfaces. A common solution for perforated shades is to use a light color on the outside facing surface for light and heat rejection when the shade is closed, and a darker color on the inside because it allows for better visual connection to the outside when closed. Shade colors should also be considered in relation to other interior finishes in the building.
  - Consider how the shades will be controlled. Automated shade control can be programmed to maximize daylight availability while preventing glare from direct sunlight, or to automatically close the shades outside of normal business hours to prevent unnecessary heat gain or heat loss. Programming may be based on calendar settings that consider solar angles or based on sensor inputs that respond to actual conditions. Consider how the controls programming will respond to a manual override. The control system may be set to revert to the standard programming after a specific amount of time following a manual override, at the end of each day, or only when an occupant provides an input to revert to the programming.
  - A clearly written specification that includes both electrical and architectural scopes of work is essential. The specification should be performance based and include the backing needed to support the shade and list voltage requirements if the shades are wired. Further, it is key to identify who will be responsible for design, drawings, and installation of each component.

3.2 Lighting

Although the lighting and lighting controls portion of the INTER system retrofit is relatively similar to any standard lighting retrofits or upgrades, there are some additional factors to consider, as outlined here.

- ***Is the site suitable for a lighting retrofit?***
  - Commercial sites with standard 2'x4' or 2'x2' suspended grid ceilings and typical fluorescent troffer fixtures tend to be best suited for highly cost-effective lighting retrofits. A wide variety of LED "retrofit kits" are available on the market that allow for high quality lighting system upgrades with minimal disruption. These retrofit kits may also include integrated occupancy and daylight sensors, eliminating the need to install and wire separate sensors.
  - Other non-troffer or custom existing lighting systems may also be well suited to lighting retrofits. The adaptability of current LED technology can enable customized lighting retrofit solutions in scenarios that may not have had effective retrofit options in the past. Although upgrades to non-standard lighting systems may entail greater first costs, they can also result in more dramatic energy savings and light quality improvements, especially for older lighting systems.
  - Sites with existing lighting controls systems may also be well suited to an INTER system lighting retrofit. A retrofit can build on the existing controls infrastructure to improve the functionality of the controls system, add new capabilities, and even integrate with the HVAC system to provide additional energy savings.
- ***What to consider when specifying retrofit lighting and controls:***
  - Although the INTER systems approach does not require Luminaire-level Lighting Controls, or LLLC (i.e., a daylight and occupancy sensor embedded in every light fixture), this approach provides more control granularity without the need to specify control zones. This is especially true for daylighting controls where access to daylight and daylight conditions can change throughout the day, especially at greater distances from windows or with other obstructions.
  - Lighting sensor and control communication protocols should be capable of communicating with the HVAC control system if the lighting sensors are also used to provide occupancy-based control for the HVAC system.
  - Daylight sensors and controls software should have fine-tuned light level monitoring to adequately adapt to changing light conditions from the shades, and to accommodate the indirect daylight when the shades are open, as well as the direct reflected light from the light-redirecting blinds.
  - Ensure that replacement luminaires will meet or exceed light levels provided by the existing lighting system, as well as meeting lighting standards as established by the IESNA or other professional lighting organizations. In many cases, LED retrofit kits will provide light levels in excess of the existing system, allowing for institutional tuning, or dimming all of the new fixtures below full output to provide additional energy savings while maintaining high quality lighting conditions.

3.3 HVAC Retro-commissioning

Although the INTER system retrofit can result in HVAC energy savings without retro-commissioning, the controls integration and implementation of ASHRAE Guideline 36 control sequencing can help to optimize those energy savings and bring additional savings by tuning the HVAC system controls. Considerations for retro-commissioning are outlined below.

- ***Is the existing HVAC system suitable for retro-commissioning and controls integration?***
  - The existing HVAC system should be a multi-zone variable air volume (VAV) system to implement occupancy-based zone setback.
  - HVAC systems will need to have direct digital control (DDC) or be updated with DDC to integrate with occupancy signals from the lighting control system and to implement Guideline 36 standards.
- ***What to consider when specifying HVAC Retro-commissioning:***
  - Specifiers, building operators, and the systems integrator should coordinate and review the existing system characteristics and capabilities to determine which Guideline 36 controls sequences will be feasible and most effective for the site.

3.4 Communication Protocols and Integration Considerations

In addition to the details of the component systems themselves, another key consideration for an INTER system retrofit is communication protocols and integration, as outlined below.

- ***How will the component systems need to communicate with each other and with building occupants and operators?***
  - Consider which systems need to communicate directly, and which systems are communicating indirectly. For example, the lighting control system may not require direct communication with the shade controls because the lighting sensors will automatically adjust to any change in shade position based on the amount of light in the space. On the other hand, lighting sensors will need to communicate directly with HVAC controls software to enable zone-based occupancy control for the HVAC system.
  - Consider how building occupants will interface with the INTER systems. To what extent will occupants be able to override automated systems operations? And how will those overrides operate? For motorized window shades with automated networked controls, for example, occupants may have a handheld remote control, a wall-mounted controller, a control app on a computer or smartphone, or some combination of those, to make manual adjustments.
  - Consider whether the building has a dedicated operator or facility manager, and their needs for managing the system. What are the building operator's preferences system defaults versus active management of the system? How will the INTER system interface with existing BAS or EIS systems? What are the building operator's preferences for communications settings and alerts from the INTER system?

- ***What type of communication infrastructure will be required?***
  - Consider whether the INTER systems can integrate with the existing IT infrastructure in the building, or whether a dedicated network is required for building systems. Existing IT networks for business file storage and sharing may have security features that inhibit the operation of the building systems, or existing IT security policies at a site may prohibit integration with building systems. As an alternative, retrofits may implement a dedicated building systems network that allows for communication between building systems without conflicting with other existing IT network functionality.
  - Consider whether the selected systems are able to communicate with each other as-is, or if a third-party communication network is required to enable the necessary communication pathways. Some systems may have common communication protocols that allow for relatively seamless integration, while others have propriety systems that may require additional steps or translations to communicate to external components.
  - Plan for communications infrastructure at the outset of the project. Whether for communication between systems or communication between components of an individual system, effective control communication is essential to the operation of INTER systems. Many retrofit systems use wireless communication protocols to minimize wiring in existing buildings, but those wireless components require sufficient support infrastructure (routers, control hubs, etc.) with sufficient capacity to operate properly.

4 Contracting and Installation Process

The process for installing an INTER system can be broken into three primary sections, plus a fourth depending on the skills of the various installers. These sections are:

- Lighting and lighting controls retrofit and installation
- Shades and shade controls installation
- HVAC update and retro-commissioning
- Systems integration

These different sections are typically performed by different contractors with different skill sets and knowledge. Each should be capable of performing their individual tasks and most of the work does not need to substantially overlap with the other portions. If this work is done as part of a larger renovation effort, there may be multiple contractors in the facility at the same time, in addition to those needed for the INTER package installation.

However, there is one situation where the efforts of the systems may overlap: the communications network and connections to the cloud for the controls and monitoring. These systems (for the lighting controls and the shading controls) are possible to overlap in a single network system and therefore, they could be combined to reduce cost and hardware that will be installed in the facility. This will be entirely dependent on the specifications of the equipment selected. More details follow with the individual systems discussed below.

4.1 Lighting and Lighting Controls

The lighting system will be installed by a contractor that is knowledgeable in lighting retrofits. In some cases, the manufacturer of the lighting and controls system selected may partner with approved contractors to ensure that the contractor has the training needed to efficiently and properly install the system in a building.

However, if the specification is for the more advanced and beneficial features of an LLLC lighting and controls system, there are two components of the installation that may require additional attention to ensure that there aren't gaps in the budgeting and responsibilities to ensure that the project is completed efficiently. These are:

- Networking changes that may be needed to provide the lighting controls system with the appropriate data and connectivity needs. This will often be performed by an electrical contractor that specializes in the IT portions of a building (low voltage and communications wiring), and there may be a need to make connections to the main IT system as well, so there will likely be coordination and involvement with the IT and security group in the building.
- Integration of the lighting information into the HVAC system (if possible) will require that data coming from the lighting control system be exported to the larger building system (which should be done by the installing lighting contractor as part of the system setup and commissioning), but the HVAC system will need to also be set to be looking for inputs from the occupancy sensors in the lighting control system. This coordination is often completed by a systems integrator or may also be done by an HVAC contractor who specializes in the controls of the HVAC system.

Coincidentally, the shades control system will likely also need some IT installation and networking support, so some of this effort may benefit more than just the lighting controls system.

4.2 Shading and Shading Controls

Shading systems are traditionally installed by a company that specializes in commercial shading system installations. However, this has traditionally not been a market that has had a lot of technology to install, so there are many shading contractors who may not yet be suitably trained to work on the installation of advanced motorized shades and controls systems that are a key part of the INTER system.

The shading control system can follow two different approaches:

1. A wireless control system (and a solar-based power system), or
2. A wired system.

In both cases, there will be a need for some IT technology installations related to the controls system. However, the differences may be substantial because a traditional wired system doesn't normally also have a control system to ensure automated controls capabilities as the INTER system requires.

Considerations and characteristics for shading controls strategies are outlined in the table below:

Wireless control systems	Wired control systems
♦ Better for integration with other building systems, such as with the INTER approach ♦ Ideal for retrofit scenarios to minimize wiring installation costs ♦ Potential to monitor shade positions and automatically adjust for changing conditions (weather, schedules, etc.) ♦ Requires solar-based power system or other mechanism for powering motors ♦ Requires IT coordination to integrate wireless communication and control system set up. ♦ Still requires power wiring to control system components such as network hubs, typically located in IT closets or ceiling plenum (also requires electrician coordination for power wiring)	♦ Better suited to new construction ♦ Spaces where shade control is not integrated with other building systems ♦ Spaces where large groups of shades need to be controlled together ♦ Spaces with transient or changing occupancies ♦ Spaces with needs for controlling shades based on changing uses (for example, room darkening for video or projector) ♦ Ability to provide power directly through control switch ♦ Does not require centralized control system ♦ Requires electrician coordination to provide power to the shade motor (typically low-voltage power)

4.3 HVAC Retro-commissioning

HVAC RCx is typically only done by the contractor who is responsible for the maintenance and monitoring of the HVAC system in the facility. This contractor can be tasked with developing a new sequence of operations (SOO) for the HVAC system if it is capable of improvement based on the newest recommendations in ASHRAE Guideline 36 (G36). This includes the use of "occupied stand-by" and similar controls approaches that leverage the occupancy information that is provided by the lighting controls system.

However, many of the HVAC systems may require some updating to fully leverage the G36 approaches, if the system in the facility will even allow it. The HVAC maintenance contractor will be able to assist in determining whether these approaches are viable with the equipment in the facility.

The specific details of a G36 implementation should be coordinated and managed by an independent consultant to ensure the retro-commissioning can produce the most effective implementation of the G36 controls approaches. This effort should include the evaluation of the hardware on site for capabilities and also trending of pre- and post- RCx to ensure that the new SOO is implemented and is functioning as expected.

4.4 Systems Integration

A systems integrator is employed on some construction projects to ensure that the various building systems are working together well and properly communicating to provide energy efficiency and a robust, fault-tolerant system.

In a project like the implementation of the INTER approach in a facility, there may be the need for systems integration to ensure that the occupancy information from the lighting controls is passed to and acted upon by the HVAC system. There is an amount of data processing that may also be required, depending on the information that the lighting system is passing to the building automation system (BAS). This has to do with data aggregation, or the collecting of the individual occupancy "hits" in an HVAC zone so that data is passed to the HVAC system at the zone level rather than at the occupancy sensor level.

Some lighting systems may do this aggregation internally before passing it to the BAS, but others may not, so the coordination of these details will be necessary.

4.5 Installation Details

The various contractors involved on a project like this require coordination among the teams to ensure that the installation process is smooth and produces the least disruption to the facility as possible. This role may fall to a general contractor.

Individually, much of the work on each portion of the INTER package does not require extensive coordination to facilitate the retrofit work because the tasks are either not overlapping in the space or they are not so time intensive that it becomes a difficult problem to work around. The lighting retrofit work happens in each room in a matter of hours, and then moves on, and similarly, the shades installations happen quickly as well. The HVAC work likely will not overlap spatially on the others at all.

However, there is a substantial benefit to coordinating on the IT needs of these systems because there will be a more efficient discussions of all the IT needs of the various building systems if they are presented in combined conversations with the facility IT personnel. IT personnel are tasked with ensuring both the viability and the security of the connected building systems and will likely be able to manage the changes better when combined. As noted earlier, bring the IT department into the retrofit design at the start and secure understanding and support. If coordination or confidence is lacking, assure the owner's representative provides clear direction from the start that the owner supports this building upgrade.

5 Facility Manager and Occupant Interface and Education

There are many operational considerations that a facility manager should be aware of when contemplating the installation of an INTER package of measures. While some of the changes will be less noticeable from the perspective of operational impacts, some of the changes are substantial and require more attention to ensure that the system continues to operate effectively into the future. The following is a list of potential impacts that a facility manager should be aware of.

5.1 Increased Maintenance of Some Systems

A fully manual shading system will require very little maintenance as the system ages as long as the system installed is sufficiently robust for the anticipated use. However, a motorized system introduces spindle motors, a motor control system, a battery and solar panel (if solar powered), and additional shading controls connected to the network to provide the automation. This is a significant increase in system complexity and will mean that more maintenance will be necessary to keep the system functioning properly.

There will be physical maintenance requirements and also software or firmware updates that may be needed to ensure the system is functioning and updated to ensure potential security exploits are eliminated and to update functionality of the control system.

5.2 Shading Automation Controls Data Subscription

The industry of building controls has moved toward annual membership subscription models so there will likely be an annual expense associated with running the automation and tracking software through the cloud. This can be beneficial, because it should also mean that there is an organization out there that is familiar with the installed system and able to provide technical support when there are needs to make changes or correct problems. This can be beneficial when the facility has a change in the spaces (like a renovation with moved walls or added walls to a space) that would require making controls edits. These changes won't likely be possible without the assistance of the company managing the controls software. Some of the likely features of a shades control subscription model are listed below:

- Regular status reports for the shades to monito for shade maintenance issues.
- A cloud-based "dashboard" to see the real-time status of the shades and perform some building-wide changes to the schedule of operation or make temporary overrides to the programming for special needs.
- Call-in technical support on shades control issues or problem-solving.
- Training videos and other training documentation to educate the building staff and occupants on the building shades operations.
- Materials (instruction sheets, QR codes, and apps for download) to make the occupant controls experience smooth and effective.

- Support for reconfiguring the shades in the building based on new needs/requirements or renovations.
- Ongoing monitoring of the system remotely be a trained expert to ensure that problems are addressed quickly to minimize system down time.

5.3 New Staff Training Requirements

With the INTER system of measures, some additional training of the facility staff will be necessary so that they are familiar with both the operation of the hardware and software of the INTER devices, but they also need to understand the intent of the systems so that work that is done in the spaces does not defeat the benefits that the INTER system can bring to a building.

This means that the facilities team need to understand how the systems are working and how they interact and why they are doing the things they do. With this understanding, they can make repairs and modifications to the building as needed to ensure proper operation of the whole building (including the INTER components) without doing things that will inadvertently defeat the benefits of the INTER system. Training for the facilities staff should include:

- Hardware requirements for regular maintenance
- Uncommon maintenance items
- Programming interface devices (cell phone, switches, computer, etc.)
- Energy monitoring dashboard
- Status monitoring of devices through the dashboard
- Additional training to assist the occupants with questions and problems

5.4 New Occupant Training Requirements

Occupants of the spaces that include the INTER system need training so that they understand how to use the system interfaces without too many calls to the facilities staff for support.

In addition, they need to receive training so that they understand what the shades and lights are doing and why to encourage buy-in. This will also reduce calls to the facilities staff for complaints and adjustments.

The occupants may also need to be logged into the control system, depending on the details of the shading controls. Since there is likely to be a connection to the controls system through a cell phone app or a small app on a computer, these access pathways have to be managed and gateways permitted based on a specific person's authorization to control the shades and lighting in their space. Without this management, it is not possible to permit connected controls of that nature to occur in the building and all controls will need to be locked to specific switches physically located in the room with the shades.

The following topics should be included or provided with training to improve occupant retention:

- A video or slide presentation of the functions of the shading and lighting systems[1]
- Information on how to download and install a phone app for the controls
- A "cheat sheet" of main tasks or operations that will commonly be done with the system
- Contact information for the appropriate facilities staff member to provide help when needed
- An explanation of the functions and the reasons why these systems were installed in the building. This needs to explain the benefits of this system to the occupant, not just the larger possible energy savings benefits of the system. This should focus on the user-flexibility of both the lighting and the shades so that they understand that this is a benefit for them personally, that they can leverage as they feel is most suitable for their needs.

[1] A 2 minute user instructional video for the INTER system shade controls was developed as part of the Leading in LA project. It is located on the project page here https://newbuildings.org/resource/leading-in-la/

6 Costs

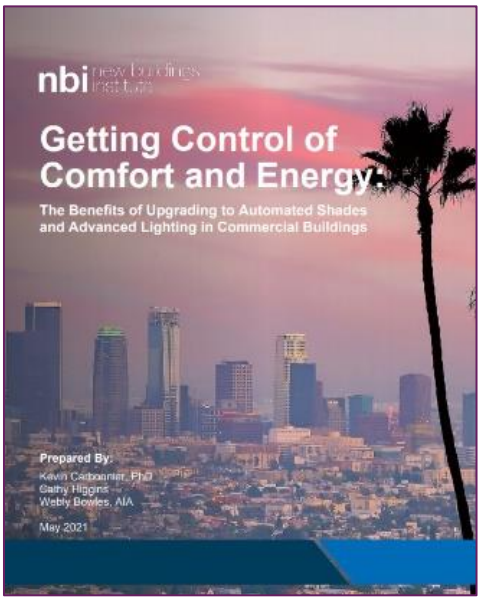
Costs for an INTER systems retrofit can vary widely depending on the systems included, the material and design specifications, and the existing systems and conditions at the site.

Specification choices that result in increased equipment costs may also provide savings in design, installation, or long-term maintenance. For example, an LLLC approach (where sensors are built in to each light fixture) may increase the cost of the lighting system equipment, but reduces or eliminates the need for complicated controls zoning, separate wiring for control sensors, or battery replacements on separate wireless sensors. On the other hand, in applications where the granularity of LLLC is not required (such as small private offices), the added cost may not be justified.

Similarly, the costs of the INTER systems components must be considered beyond just simple payback in energy savings. While the automated shades system behaves like a building system, the cost of the shades should be considered in relation to other high-end interior finishes and tenant expectations. Furthermore, the cost of these improvements must be considered in relation to the amenity benefits they provide, such as improved light quality and access to views, which are known to produce productivity and health benefits for occupants.

7 Making the Case for INTER

Before you can design, specify, and install an integrated system of advanced technologies the case needs to be made that the system is valuable to the owner, operator, and/or occupants. While energy savings can be a substantial outcome of the system, the advantages to occupants and to operations associated with the INTER system are often the compelling factor in a decision to upgrade.



Getting Control of Comfort and Energy in Offices is a new market-facing Benefits Guide of integrated systems upgrades and automated shades with advanced lighting. Snapshots of benefits and energy results from the summary are below. Share this Benefits Guide with clients and colleagues to prime their knowledge and acceptance of advanced technologies and integrated systems.

Benefits of Automated Lighting and Shading Systems

Owners
Modernized building
Reduced operating costs
Higher tenant satisfaction

Occupants
Personalized control
Thermal comfort
Elimination of glare
Maintained views

Operators
Centralized data and control
Reduced maintenance of lamp change outs
Reduced comfort complaints

Figure 3: Benefits of Automated Lighting and Shading Systems