LIGHTING CONTROL USER INTERFACE STANDARDS

USER INTERFACE STANDARDIZATION FOR THE PROMOTION OF ENERGY-EFFICIENT PRACTICES

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Lighting control user interface elements are governed by few standards. This may lead to products that are unnecessarily confusing for building occupants, leading to a lost opportunity for energy savings. The problem may worsen as control capabilities rise sharply with the advent of digital and networked systems.

The Lighting Control User Interface Standards project documented existing and emerging user interfaces for lighting controls and collected input from industry leaders and policymakers on the need for a lighting control user interface standard on selected elements, and a process by which to design and create it.

The project team concluded that standardizing selected elements would be accepted by the lighting industry.

SURVEY CLOUD SAMPLE

Switches

Color Controllers

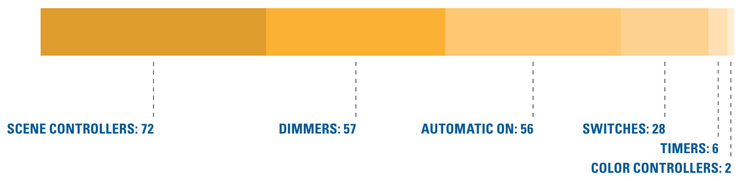
Scene Controllers

Timers

Dimmers

Automation Controllers

CONTROLLERS SURVEY



BACKGROUND

The Lighting Control User Interface Standards project is an initial investigation. Additional phases should follow that will conduct more detailed research, draw up possible content for one or more standards on the topic, and pursue adoption of those by appropriate organizations. The project was inspired by a California Energy Commission PIER project that saw final approval of an Institute for Electrical and Electronic Engineers standard.

The underlying proposition for both projects is the same: consistent user interfaces can improve usability of products and lead to energy savings. Consistency comes from standard elements of user interfaces, and the standards work best when they have the backing of a recognized standards organization. If the user perceives the room's lighting controls as overly complex or confusing, the likelihood of energy-efficient lighting use for the space may decline.

TECHNOLOGY AND RESEARCH APPROACH

The research team conducted a Survey of Existing Controls to collect, document, and analyze the common elements found in residential and commercial controls that the average occupant regularly comes into contact with.

The survey focused on the elements of common lighting control user interfaces, including switches, dimmers, and scene controllers found in homes and office spaces. Visual, tactile, and audio elements that serve as cues or feedback also were taken into account. The survey excluded control panels and software-based systems that are specific to facility and energy managers.

DEVICE INPUT & MOBILITY

Any lighting control interface that a user does not move regularly is considered fixed, even if the controller itself is wireless or moveable under certain conditions. Any lighting control interface that the user moves on a regular basis as a part of the operation of the lighting in a space is considered mobile.

LIGHTING TAXONOMY

Audit of lighting controls in today's marketplace

Product images were collected and categorized based on whether they would be encountered by an end user or a professional energy/facility manager; interface complexity; mechanical or screen input; mobility; visual cues; and dynamic feedback elements. The collection was used to develop a taxonomy that represents the most common features of lighting control interfaces that are used in residential and commercial environments; the majority of the items surveyed can be found in either environment. The residential products serve as a baseline as they are typically less complex and sold at lower prices. The products were selected from 44 companies, including 28 lighting, eight home automation, three home improvement, two electric, and three others.

VERTICAL/HORIZONTAL MOVEMENT

	SWITCH		SLIDER		
INPUT	**MECHANICAL INPUT**		**MECHANICAL INPUT**	**HYBRID INPUT**	**DIGITAL INPUT**
INTERFACE	 **TOGGLE**	 **ROCKER**	 **DIMMER**	**TOUCH SLIDER**	 **DIGITAL DIMMER CONTROLS**
MOVEMENT	▸ Move toggle up & down	▸ Move rocker up & down/right & left to change states	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease ▸ Tap different intervals to jump levels	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease ▸ Tap different intervals to jump levels
APPLICATION	▸ On/off	▸ On/off	▸ Dimming, on/off	▸ Dimming, on/off	▸ Dimming, on/off
VISUAL CUES	▸ TEXT: On/Off ▸ TACTILE: Raised text	▸ TACTILE: Raised nib, usually to signify the "on" state, click for on/off	▸ TEXT: On/Off ▸ TACTILE: Click for on/off ▸ VISUAL: One button and one slider	▸ TACTILE: Raised nibs indicating different levels ▸ VISUAL: Indicator lights for level	▸ TEXT: Numbers noting different levels, text for increase/decrease ▸ SYMBOL: Increase/decrease ▸ COLOR: Brighter colored node
POSITION/STATE	▸ Two states locked at either on/off	▸ Two states locked at either on/off	▸ Slider position moveable from 0% (off) to 100%	▸ Slider position moveable from 0% (off) to 100% ▸ User can jump to different levels instead of gradually changing levels	▸ Slider position moveable from 0% (off) to 100% ▸ User can jump to different levels instead of gradually changing levels
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Mechanical click, perceptible to touch ▸ AUDITORY: Soft click	▸ TACTILE: Mechanical click, perceptible to touch ▸ AUDITORY: Click	▸ TACTILE: Mechanical click, perceptible to touch	▸ VISUAL: LED indicators showing dimmer levels ▸ AUDITORY: Beep, click	▸ TACTILE: For some interfaces, there is no tactile feedback. Some systems include a vibrating feedback to show that the user input was acknowledged. ▸ VISUAL: Marker node shows what level the dimming is on. Other systems, particularly online interfaces whose response time is dependent on Internet speed, sometimes display an icon (i.e. hourglass, clock, spinning wheel) showing the passage of time, indicating that the system has registered the user input and is in the process of updating the system state to reflect the change. ▸ AUDITORY: Tone
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ The system indication is binary in this case, since it only allows for two states.	▸ Lights turn on/off ▸ The system indication is binary in this case, since it only allows for two states.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ Actuation is indicated if the node is not in its off position	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ LED indicator notes at what level the system is set.	▸ Lights turn on/off ▸ Light level increases or decreases. While looking at the lights, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. However, the GUI slider shows what level the system is set to.

IN/OUT PUSH MOVEMENT

	SWITCH		
INPUT	**MECHANICAL INPUT**	**HYBRID INPUT**	**DIGITAL INPUT**
INTERFACE	 **SCENE CONTROLLER**	 **TABLETOP TOUCH PANEL CONTROLLER**	 **WALL-MOUNTED TOUCH PANEL CONTROLLER**
MOVEMENT	▸ Push button to change states or increase and decrease	▸ Push button to change states or increase and decrease	▸ Select "buttons" or links to change states, select what aspect of the system to modify, or increase and decrease
APPLICATION	▸ Change states at set intervals (scene controllers, dimming)	▸ Change states at set intervals (scene controllers, dimming)	▸ Change states at set intervals (scene controllers, dimming)
VISUAL CUES	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ TACTILE: Raised nib to highlight special keys ▸ SYMBOL: State changes	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ TACTILE: Raised nib to highlight special keys ▸ SYMBOL: State changes	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ VISUAL: Buttons on digital interface often aesthetically look like a physical button (shading) to carry over metaphor. In this case, "Links" or words that are selected also can be seen as a button in its in/out movement
POSITION/STATE	▸ The physical interface of a button can only be in two states—pressed down or not pressed (no action for half-depressed button) ▸ Multiple buttons (combined with visual cues) can prompt the user to increase/decrease states at set intervals between 0% and 100%, or to change states	▸ The physical interface of a button can only be in two states—pressed down or not pressed (no action for half-depressed button) ▸ Multiple buttons (combined with visual cues) can prompt the user to increase/decrease states at set intervals between 0% and 100%, or to change states	▸ Depending on the visuals of the interface, "buttons" often have an appearance of a push movement, indicating user input was registered
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Mechanical click, perceptible to touch ▸ VISUAL: Indicator lights showing power on/off (sometimes increase/decrease) ▸ AUDITORY: Tone, click	▸ TACTILE: Button pressed down, tactile feeling of state change from rest to pressed down ▸ VISUAL: Indicator lights showing user input was registered. IR light turns on for remotes that rely on IR to transmit user input. ▸ AUDITORY: Tone, click	▸ TACTILE: In some cases, vibration signifies change in state ▸ VISUAL: "Button" changing appearance (color, bolded text, highlighted, etc.), mimicking a pressed-down button. Other systems, particularly online interfaces whose response time is dependent on Internet speed, sometimes display an icon (i.e., hourglass, clock, spinning wheel) showing the passage of time, indicating that the system has registered the user input and is in the process of updating the system state to reflect the change. ▸ AUDITORY: Tone, click (reminiscent of a clicking hardware button)
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ Lighting scenes change ▸ Some scene controllers have indicator lights showing on which scene the system is set, or the active scene button remains depressed until a different scene is chosen. However, with most interfaces, there is no indication if a state is already active, often warranting re-input of user commands to determine system activity.	▸ Lights turn on/off ▸ Lighting scenes change ▸ If the interface includes a screen, text or symbols on the screen will indicate what state the system is in. ▸ Button does not remain depressed once a scene is selected, so there is no indication if a state is already active or if the input was or was not registered, which often warrants re-input of user commands to determine system activity.	▸ Lights turn on/off ▸ Lighting scenes change ▸ The GUI of the system indicates which actions are active.

ROTATIONAL MOVEMENT

	SWITCH		
INPUT	**MECHANICAL INPUT**	**HYBRID INPUT**	**DIGITAL INPUT**
INTERFACE	 **DIMMER**	 **CIRCULAR DIAL REMOTE**	
MOVEMENT	▸ Rotate clockwise or counterclockwise to increase or decrease	▸ Rotate clockwise or counterclockwise to increase or decrease	▸ Rotate clockwise or counterclockwise to increase or decrease
APPLICATION	▸ Dimming (usually gradual change)	▸ Dimming (usually gradual change)	▸ Dimming (usually gradual change)
VISUAL CUES	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability
POSITION/STATE	▸ Full rotation movable from 0% (off) to 100% ▸ Increase/decrease at set intervals between 0% and 100% for some dial interfaces ▸ Dimmers often have the push functionality of a button for on/off	▸ Full rotation ▸ For hybrid inputs that rely on signals from a remote to a system, there often is not a start and stop point for the rotation, so the user has a full 360-degree flexibility for movement.	▸ Full rotation movable from 0% (off) to 100% ▸ For some inputs, there often is not a start and stop point for the rotation, so the user has a full 360-degree flexibility for movement. ▸ Increase/decrease at set intervals between 0% and 100% for some dial interfaces ▸ User can sometimes jump to different levels instead of gradually moving from 0% to 100%
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Kinetic click ▸ VISUAL: Indicator lights showing increase/decrease (sometimes showing power on/off) ▸ AUDITORY: Tone (sometimes increasing in volume), click	▸ TACTILE: No tactile feedback ▸ AUDITORY: Tone (sometimes increasing in volume), click	▸ TACTILE: Mostly no tactile feedback, although some systems simulate a vibrating "click" when states are changed ▸ VISUAL: Indicator lights. Unlike vertical/horizontal and in/out push movement interfaces, rotational movement ▸ AUDITORY: Tone (sometimes increasing in volume), click
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ Color change for color-mixing systems. ▸ For systems that have a flush rotary interface that does not include mechanical parts to change the levels, there is no indication of actuation unless the user inputs commands.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ The GUI of the system indicates which actions are active.

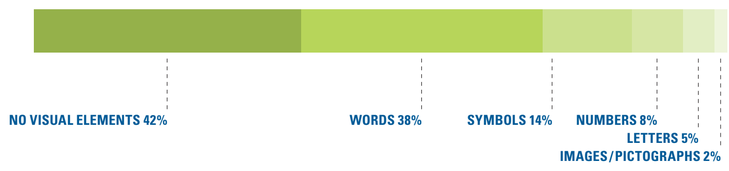
LIGHTING CONTROLS: FORMS & INTERACTIONS

Lighting controls include fixture-integrated switches/dimmers, wall-box switches, dimmers, programmable dimmers that control several scenes, and home automation systems that also control other systems (i.e., heat/air).

A controller that primarily turns a light on or off is a switch. A device used to control the intensity of light emitted by a luminaire is a dimmer. A unit capable of controlling multiple lamps, light settings, and/or lighting zones is a scene controller. A residential control system that also controls other systems is home automation. A handheld mobile lighting control device that the user moves on a regular basis is a remote.

STATIC ELEMENTS: VISUAL CUES

Visual elements assist occupants in understanding lighting control functions before touching the controller. Visual elements commonly include words, symbols, numbers, letters, and pictographs. The following graph shows the visual cue distribution from the survey.



DYNAMIC ELEMENTS: FEEDBACK & STATE CHANGES

Occupants receive feedback from lighting controllers via visual, tactile/haptic, and audio methods. The surveyed lighting user interfaces used a combination of these elements, although some interfaces did not employ visual cues beyond the positioning of the control on the wall in an area where a light switch commonly would be found.

NEXT STEPS

Standardization for industry-wide clarity

Basic power control (on/off), dimming/brightness, scheduling and timers, occupancy sensing, daylight sensing, color control, and scenes are common core concepts in lighting controls. These concepts often are communicated through user interface elements depending on whether it is an indicator or an actuator.

MANUFACTURER FEEDBACK

The project team continues to collect manufacturer and standards organization feedback as the next phase of the project is planned. To date, 11 companies provided feedback on UI standardization: Six companies were supportive, and five companies expressed skepticism. The majority of the doubtful comments were on the potential for proprietary design constraint and a possible decrease in unique product identification as the result of standardization.

CONCLUSIONS

It is important to determine the core lighting control user interface elements that cross over the myriad products in the market. While this survey is an initial map of the fundamental aspects of controls, including static elements, user interactions, and dynamic elements, further effort is needed to clarify the lighting control interface elements taxonomy.

The ultimate goal is to develop an industry standard for select lighting control user interface elements to better match lighting desired to that delivered and so save energy in residential and commercial buildings.

POTENTIAL ELEMENTS FOR STANDARDIZATION:

- **Establish a standard language/dictionary for lighting user interfaces (controls in terms, symbols, colors, and actuation methods)**
- **Further investigate the possibility of dimming, occupancy, and daylighting element standardization**
- **Establish demand response event indicators**

LIGHTING

For controls that cover only lighting, the fact that lighting is involved is almost always implicit. For those that cover other energy services, the general concept of lighting comes into play. The most common symbol is the incandescent light bulb.

DIMMING/BRIGHTNESS

Traditional dimming is a static adjustment by the user; it seems likely that dimming by other means (e.g., daylight sensing) would be indicated by that concept. Dimming has the usual physical mappings for up, clockwise, etc., and many symbols exist for showing control.

SWITCHING

Although this is the most basic aspect of lighting control, it is not clear that a single word or phrase completely captures the concept. A symbol for lighting in general exists, but it is more about the light, not the control of the light.

DYNAMIC CONTROL

This category determines how lighting controls behave automatically in response to signals from sensors. They include occupancy/vacancy sensors, daylight sensors, and transitions, which are short-term states between relatively stable light modes.

SCENES

This is a set of control settings that often includes different brightness levels for multiple light sources.

SCHEDULE/TIMES

Schedules are most likely found on a screen interface and can reference the concepts of a calendar or clock. Mechanical clock timers have been around for decades and use a clock dial to show time dependency.

COLOR

Although this is a young area for lighting control, it seems likely that the word “color” and an RGB symbol will be commonly used to indicate these controls.

COLOR CONTROL

Tunable color, color saturation, and color temperature color technology are becoming more prevalent. New user interfaces – which use iPod-like rotary controls to adjust color – exist to accommodate this technology.

Image courtesy of Finelite

Image courtesy of Cooper Lighting

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