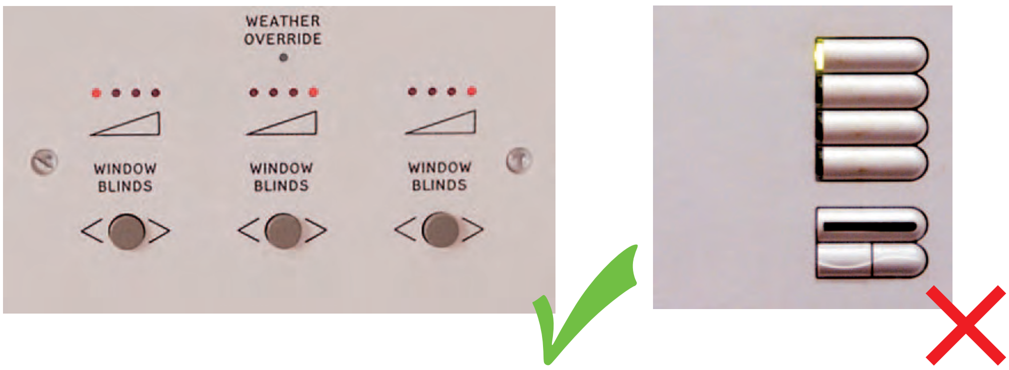
BCIA

Building Controls Industry Association

Controls for End Users

a guide for good design and implementation



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Making business sense of climate change

Controls for End Users

a guide for good design and implementation

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The guidance was drawn from knowledge and expertise in the Usable Buildings Trust (UBT), and was managed by a BCIA task group comprising Doug Robins of Priva Building Intelligence, David Kitching of Siemens, and Adrian Leaman and Bill Bordass of The Usable Buildings Trust. Roderic Bunn of BSRIA was the guide's principal author and research manager. BSRIA's David Bleicher provided quality assurance. Ann Hull of the BCIA acted as the secretariat.

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Controls for End Users: a guide to good design and implementation

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Introduction

This Guide concentrates on the strategy, implementation and the user interfaces of control devices located in occupied spaces and operated by individual users – the people for whom buildings are designed. These users want to make adjustments as quickly and simply as possible to obtain an environment that suits their needs (such as working, living and cleaning). They are not interested in the technology, only the results.

The guidance focuses on user controls for heating, cooling and ventilation – the main interests of BCIA members. It includes natural ventilation, which is increasingly important in low-energy buildings but tends to be outside the experience of the HVAC industry. It also touches upon control of natural and artificial lighting, glare and solar gain, for which the principles are often similar. It is particularly concerned with achieving good results with minimum energy use, especially through good integration of natural and mechanical systems and in avoiding equipment running unnecessarily.

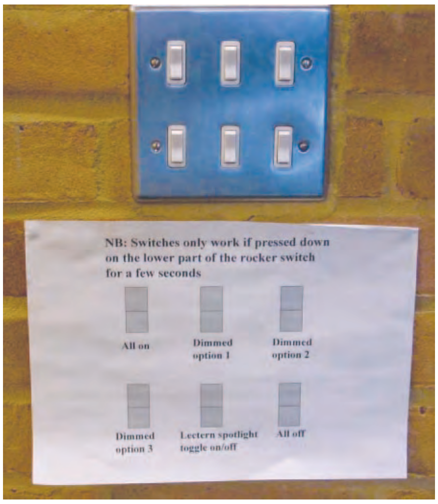
This guidance does not cover controls located in plantrooms. However, the principles of good user controls also apply, and not just because many facilities managers are not building services and controls specialists. Well-designed controls with good user interfaces benefit everyone.

The usability of local controls for lights, blinds, heating, ventilation and cooling will affect how well a building performs

Why user controls matter

Control interfaces are where the users and the technology of a building come together. The usability of local controls for lights, blinds, heating, ventilation and cooling will affect how well a building performs in many respects:

- **User satisfaction**. Case studies in non-domestic buildings reveal positive relationships between occupant satisfaction and levels of perceived control
- **Avoiding discomfort**. Occupant surveys suggest that people prefer conditions that are relatively coarsely controlled, provided that at the same time they incorporate control facilities to avoid conditions that are too hot or cold, glary or gloomy, stuffy or draughty
- **Rapid response.** The faster a building responds to human needs, the better occupants tend to like it. Rapid response is key to good user satisfaction and perceived control. The response does not have to be perfect, but it must be rapid, detectable, and in the right direction
- **Assisting management**. Only a small number of buildings have sufficient central control and facilities management support to deliver genuinely rapid response via a helpdesk. It can be more cost-effective for individual users to deal with local problems using local controls
- **Energy efficiency**. Buildings with good local controls tend to be energy efficient because systems are more likely to operate only when occupants need them. Equipment is less likely to be left on or because people have found the controls too difficult to use or do not understand what they need to do.



Better controls are an important way of saving energy and reducing carbon dioxide emissions. Usually they are a more cost-effective way of saving energy than adding renewable energy systems. To invest in renewable energy without first making sure that the controls are as effective as possible would be a waste of resources.

Unfortunately, case studies reveal that:

- Many environmental control systems do not work as well as they should – not just electronic ones, but also simple switches, window gear, sunblinds and room thermostats are often not well thought-through or well integrated
- Electronic controls can be too complex. Designs are often driven by the producer rather than the users, and may require more setting-up and commissioning than the design team, the client and the contractor think
- In a completed building, features that users and management do not understand or find complicated or confusing tend to be ignored or by-passed
- Effective user controls can be simple and unobtrusive. Simple does not mean low-technology, but simple to understand, use, operate and maintain
- The better performing systems are not necessarily expensive. However, they tend to have received careful attention to detail in briefing, design, specification, installation, commissioning and handover, and also in the user interfaces.

Perhaps the main obstacle to cost-effective, energy efficient and sensible controls is that clients seldom ask for them. They also fail to realise the effort that may be required to deliver a high level of functionality and usability to make user controls obvious and intuitive. Consequently, design and building teams are not united in their response to the usability problem, and control suppliers and installers are not geared-up to meet their needs.

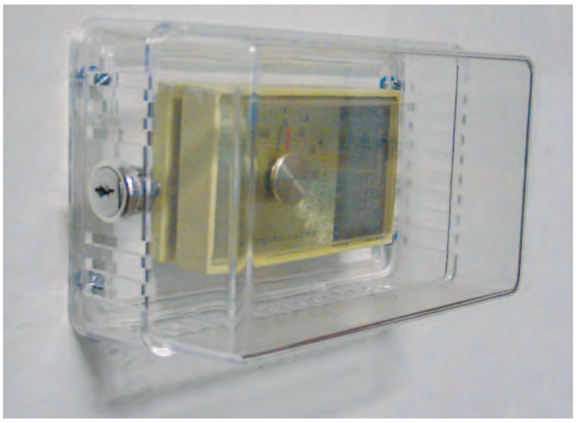
Considerable attention to detail is required to devise effective and durable controls that will do their job well and reliably. This guidance addresses ways in which the technology can be suitably configured, designed, annotated and labelled. Designers and the controls industry will also need to improve their understanding, strategy and attention to detail so that a new generation of user controls offer useful user interaction and information rather than simply extra features.

The psychology of user controls

In his book *Designing Web Usability*, Jakob Nielsen says that usability is essential because people will go away if they cannot find what they want quickly and easily. With web pages, feedback is immediate. With building controls, poor functionality will not be detected until after the designers and installers have left site.

If user controls are ambiguous in intent, poorly labelled, or fail to show whether anything has changed when they are operated, then the systems that lie behind them are unlikely to operate effectively or efficiently. Unsuccessful attempts by building occupants to get the conditions they want may then be read by facilities managers as tampering or even sabotage.

If user controls are ambiguous in intent, poorly labelled, or fail to show whether anything has changed when they are operated, then the systems that lie behind them are unlikely to operate effectively or efficiently.



Freely-adjustable thermostats can be a problem because people either turn them up too far and waste energy, or down too far and then complain about being too cold the next morning. Tamper-proof thermostats don't solve the problem: if people are hot they open the window and the thermostat calls for more heat. If it's too cold, the vandals break into the thermostat and turn it up, but the law-abiding won't break in to turn it down, so open windows instead.

Vicious circles may subsequently ensue where occupants are not allowed to make changes, and controls are over-ridden and may even be disconnected. As a consequence, both occupant satisfaction and energy efficiency tend to suffer.

The problems that arise include:

- Lack of understanding of users and their needs. This requires more knowledge-gathering by designers and controls specialists
- Lack of clarity of design intent
- Lack of design integration (particularly of natural, mechanical, electrical and control systems)
- Poorly-defined responsibilities for controls development
- Specifications poorly defined and not adhered-to
- Cost-saving pressures. These can be severe because controls are installed late in the construction process and their importance is not well understood
- Poor dialogue between controls specialists, designers, clients and users
- Lack of communication of the design intent of the control devices to users

- Inability of systems to handle low demands efficiently.

Designers, controls manufacturers and systems integrators are rarely aware of such consequences and how to deal with them. The controls specialist may be called back to site to resolve problems, but the lessons learned may not percolate back up the supply chain. Often the facilities manager will side with the controls specialist, as by this late stage neither of them has the opportunity or the budget to get to the root of the problem being complained about by the users.

In his book *The Inmates are Running the Asylum*, Alan Cooper uses the term 'dancing bearware' for feature-bloated software with complicated user interfaces: you can teach a bear to dance, but it won't do it very well. Most controls-rich buildings can also be seen as dancing bears: they are stuffed with features and functions, but always seem to promise rather more than they deliver. The shortcomings are hardly ever put right.

Overcoming the barriers

Figure 1 summarises the barriers that tend to come between the intention to provide good controls and the user experience in practice.

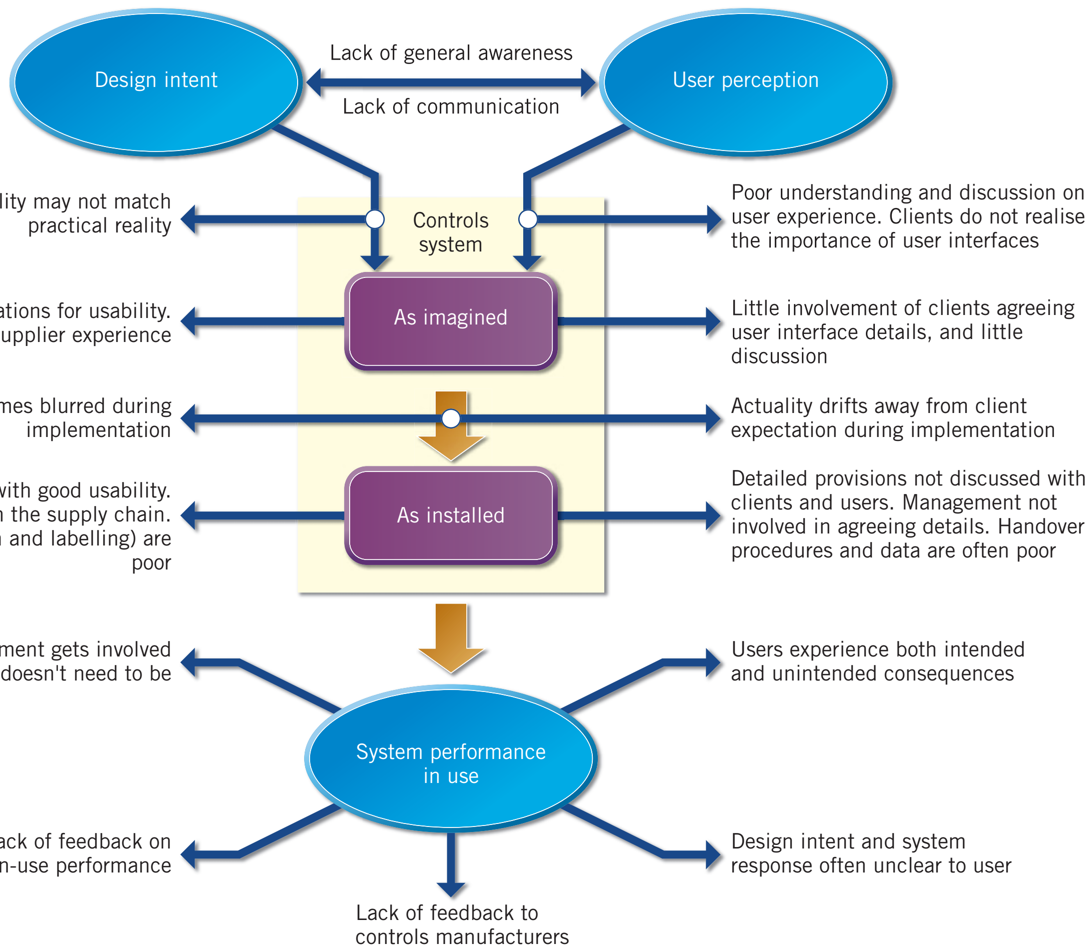


Figure 1: To the left are the intentions and activities of the design and building team. To the right are the perceptions and activities of client and users.

Building users like to work with technologies that help them to participate creatively in solutions without feeling alienated or looking silly. Good user interfaces work well because they give unobtrusive clues to the user about which actions will be appropriate.

Mechanical, direct-acting controls often map naturally onto the physical layout of the device they control, for example with door handles near the edge of a door that opens. People can usually work out what more complicated controls do if they are used in relatively well-defined situations (such as cookers in kitchens, or dashboard switches in cars), and suitably labelled.

For remote controls, some *de facto* standards have arisen over the years. For example:

- Light switches tend to be beside the door and click up and down
- Control knobs on cookers, radios and televisions turn clockwise for higher output and anticlockwise for off. They are also usually labelled for what they do
- Water taps turn clockwise for off – the opposite direction to the electrical control knobs above. However, people are quite used to this.

Innovation, electronics, and attempts to provide greater choice are tending to undermine familiar conventions and mappings. One can even buy a wall clock with a mirror-image face – known as the anti-clock. This creates variety and fun. For critical systems like car dashboards, playing with conventions in this way is inappropriate. Not only can it seed confusion, it might also be dangerous.

Many control systems in buildings are nowhere near the functionality of a typical car dashboard. Indeed, they are often far less usable than the anti-clock: they challenge rather than assist, and confuse rather than inform.

Interval timers

The interval timer is a practical and economical local control that allows a user to operate a device (or to over-ride its control setting) for a pre-set period. The system will revert to normal control after that period.

This example was developed in the 1980s to operate fan convector heaters in seminar rooms at York University. Although no longer in production, it demonstrates many attributes of good usability that are seldom present in contemporary interval timers:

- Its purpose is self-explanatory
- Users can override the system to 'off' as well as to 'on'.
- An indicator lamp (at top left) shows when the override is on.

For example, something that looks like a familiar toggle light switch may instead be a multi-function, push-button device, where successive pushes deliver different levels and/or patterns of electric light. Persistent pressing may eventually turn off the lights.

Newer controls, such as thermostats, imply one function (such as volume control via a dial) while delivering another (altering temperature set-points). This offers potential for confusion and misuse.

End-user requirements

If they are to be operated as intended, control devices designed to suit the end user should adhere to the following criteria:

- Be easy to understand and preferably intuitively obvious. If it is necessary to ask for advice or refer to instructions, ideally this should need to happen only once: what is required should become obvious after it has been explained.
- Be easy to use, otherwise people may not exercise control or choose a more convenient route
- Work effectively, with sufficient fine control to give the required level of adjustment
- Give instant, tangible feedback (such as a click) to indicate to the user that the device has operated
- Give rapid feedback to show that the intended effect has occurred (such as a readout, an indicator light, or some other form of visual indication)
- Not need to be used too often. People do not want relatively trivial decisions and actions constantly intruding on what they are supposed to be doing
- Take into account that some devices may be used only occasionally, so that people may forget basic actions.
- Not require users to intervene too much. It can be particularly frustrating where an automated system restores a default state too rapidly. (In one building, the user over-ride on its automated windows was countermanded after 60 seconds.)
- Be located as close to the point of need as possible. The point of need and the control required may vary with time and user. For example, office workers may need to adjust things from their workstations but also switch them off at the door; cleaners and security staff may have completely different requirements.

Case study

At York University, designers recognised that they needed three specifications of room thermostat, depending on the room occupancy:

- For individual offices and living accommodation, freely adjustable thermostats with high and low limits to avoid waste and freezing
- For larger rooms, such as libraries and seminar rooms, accurately-calibrated thermostats with pre-set high and low settings, selectable by the users, sometimes with interval times for the high setting in intermittently-used rooms
- For large rooms, such as lecture rooms and dining halls, control by a building management system, including occupant-responsive push-buttons in certain areas.

Selection of the best devices on the basis of durability, precision and price was a lengthy process.

Essential design principles

1 What is the control for?

Designers need to think this through carefully. User controls are provided for two main reasons:

- To allow users to select the conditions they need; or more precisely to avoid conditions they don't need. People tend to exercise control when entering or leaving a space, or if they find the conditions don't suit them.
- To help ensure that systems operate efficiently, thereby reducing a building's carbon dioxide emissions rather than contribute to them. People will tend not to exercise control if the environment is not troubling them.

2 Who is the control for?

Buildings have a variety of end-users. Needs for control vary with both with the type of user (such as regular users, visitors, and security guards) and the type of space. In small rooms, all users can often use the same devices. As spaces get larger, the requirements of different users tend to diverge.

3 Where should the controls be put?

User controls should be at the point or points of need. These include:

- The entrance to the space. This is a really important place for switching things off. Precise placement is important – for example if a control is not conveniently and immediately accessible beside the door, it may be overlooked and even get covered up with furniture.
- Near the item being controlled. This is particularly useful for windows, lights and blinds, as it assists an intuitive connection between the user, the controller and the item being controlled.
- At the point of user need. Some users need good local control in order to function. For others, it is convenient to adjust environmental conditions without moving from their workstations, such as to cancel glare from a distant window.

4 Is the design intent clear to the end users?

Does the control tell the user what it is for and how to use it? Historically, light switches, thermostats, speed controls and window and blind controls looked different. Many electronic controllers can do a wide range of things, so their purpose needs to be made explicit, in layout and labelling, to make the intent clear.

5 Is the system status clear to the users?

Often the action taken by operating a remote control will not be immediately apparent to the user: the controlled device may be completely hidden, such as a fan or an automatically-operated window that may not be visible from the point of control. Even where the item is visible there may be a delay while the buildings controls scan the system before it responds to the control. The controller therefore needs to communicate to the user what is happening.

6 Are controls well integrated and energy efficient?

Many electronic controllers can do a wide range of things, so their purpose needs to be made explicit, in layout and labelling, to make the intent clear

Good controls should operate systems efficiently when people need them and adopt low-energy default states otherwise. The general rule – manual on (or manual boost from standby) manual and auto off – is often overlooked, so automatic systems turn equipment on or up unnecessarily, wasting energy, and do not revert to low-energy default states fast enough.

Automatic occupancy sensors are good at switching things on when people arrive and off after they leave. Providing buttons and using an occupancy sensor to switch things off when they are no longer required will be more economical than purely automatic operation. Not all people entering a space will need the service.

Even though an occupancy sensor or interval timer will switch things off automatically, it is normally good to provide an "off" button, and where necessary other override facilities, to allow users to get the conditions they want and to switch things off when they leave.

Sometimes the control may need to give advice: for example, in a building with mixed-mode ventilation, to indicate whether or not the user would be well-advised to open the window.

7 How long should user override last?

There needs to be a careful balance. Too long, and energy may be wasted. Too short, and users will be frustrated.

Ideally automatic controls should ask (or tell) people how long they have got (particularly important for interval timers), or restore default states when people are absent (for example, using presence detectors at the end of the day). Where this is not possible, people can get used to default states being restored at precise times during the working day.

Examples of controls usability

While a designer or controls supplier may know what a device is supposed to do, controllers provided for those devices do not always make the device functions clear to the end-user. This section shows photographs of a range of controls commonly found in buildings, discusses their function (insofar as it is known), and ranks them on a five-point scale against six usability criteria:

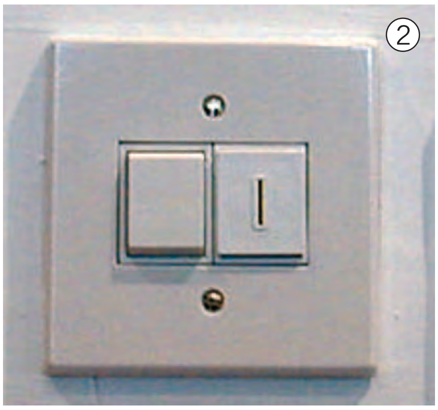
- Clarity of purpose
- Intuitive switching
- Usefulness of labelling and annotation
- Ease of use
- Indication of system response/feedback
- Degree of fine control.

The examples of controls that follow have been rendered anonymous. The usability grading is not absolute, but made by the authors based on their knowledge of the applications where the controls have been used. In most cases the criticisms and comments are directed at all those responsible in a building's supply chain – not solely the controls supplier. A lack of proper briefing is often the cause of much poor design.

Usability criteria	Ranking (controller as supplied) Poor … Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

A well-intentioned aim to give occupants some control over their environment, but with shortcomings in terms of usability, in particular the absence of any information on operating status, such as an indicator light. The control is a button, not an on-off switch. There is no indication whether the controller is already on or off, and no feedback as to what will happen (and for how long) when the button is depressed. Unless the system reacts immediately, the user may prod the button repeatedly, possibly turning the system off when they wanted it to be on.

The controller needs to have some indication as to system status, and feedback to the user when the button is depressed. Without status indication, there is also a risk that the ventilation system will default to on.



Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	●
Intuitive switching	●
Labelling and annotation	●
Ease of use	
Indication of system response	●
Degree of fine control	●

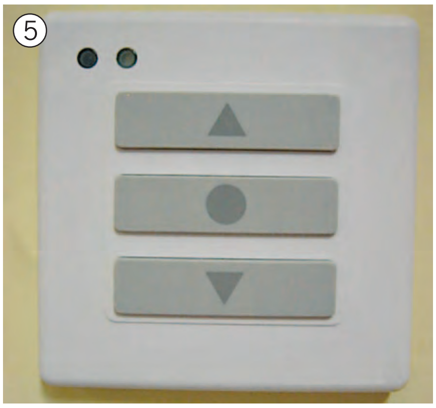
This device has no labelling or annotation. It looks like an on/off switch but is a push-button for an unidentified system. The switch is for stepless operation depending on the length of time the switch is depressed.

Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	●
Intuitive switching	●
Labelling and annotation	●
Ease of use	
Indication of system response	
Degree of fine control	●

This control for lighting has clear switching with four settings clearly illuminated, plus an off setting. The numbers by the setting are arbitrary. Apart from the numbering, the switch is not labelled as to what it does. The red light for setting 1 is on the far left of its button, hinting that there be more than one stage for each setting. Is the off button for system off, or does it apply to each of the four stages in turn? Does the vertical button to the right raise or lower the lighting generally, or on each setting? In the absence of clear annotation, the user is forced to experiment.

Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	●
Degree of fine control	

This controller is clearly a control device for ventilation. The knob at the lower left appears to offer control over a setpoint (presumably for temperature), against an arbitrary scale of plus or minus. In the absence of controller feedback, the user would need to learn the settings by experimentation. The function of the knob on the right is clearer, with three fan speed-settings, but is it for room ventilation or a fan in a heating/cooling unit? Probably the latter, as experience has forced the facilities manager to append a label telling users not to switch off the fan.

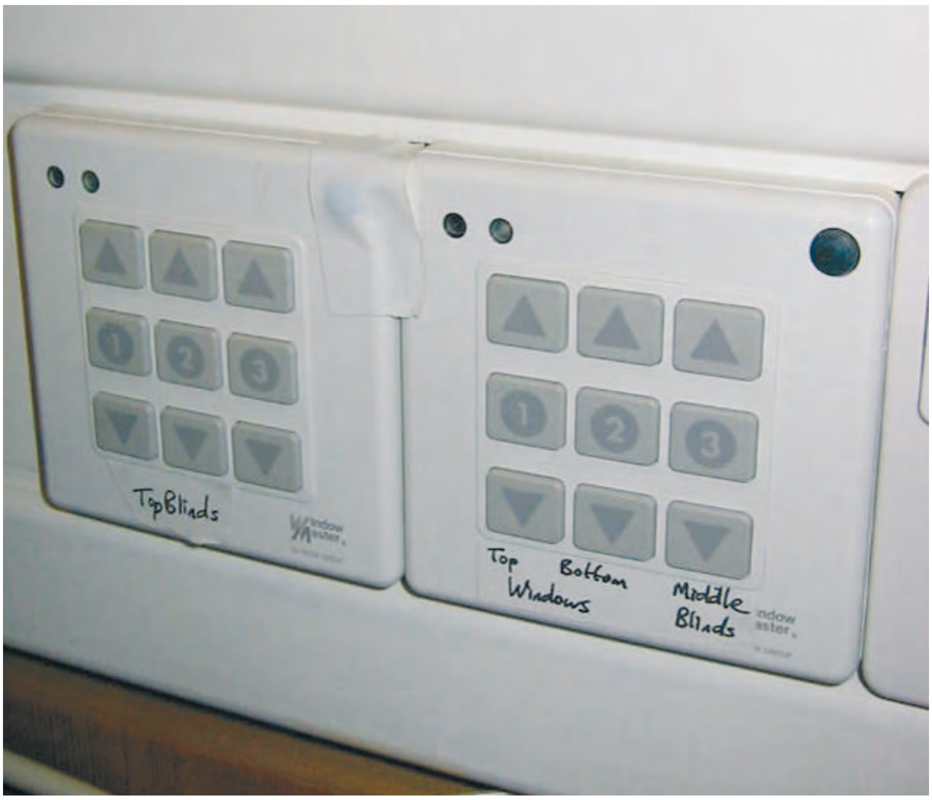


Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

This is typical of many types of off-the-shelf, generic controller. If positioned in close proximity to the device being controlled (such as a blind or a window), and in the absence of any other user control with which it may be confused, this controller may be intuitive to use and clear in its intent. Instant feedback from the device will also confirm the controller's purpose, and any fine control will be rapidly learned.

The absence of labelling and annotation is unhelpful: the occupant has to learn through experimentation, particularly if the unit is at some distance from the device under control, or is installed beside other controllers.

Being generic, the controller may have two settings: open and close; or control may be fine, with the motors only operating while the buttons are depressed; or the motors may continue to run until the centre button is depressed. Users may be alienated by a control that suggests the ability to fine-tune, but in reality gives too much or too little of what is needed.



What can happen when two three-gang controllers, similar to the example **above left**, are placed beside each other with no annotation specific to the devices under control (windows, blinds and rooflights).

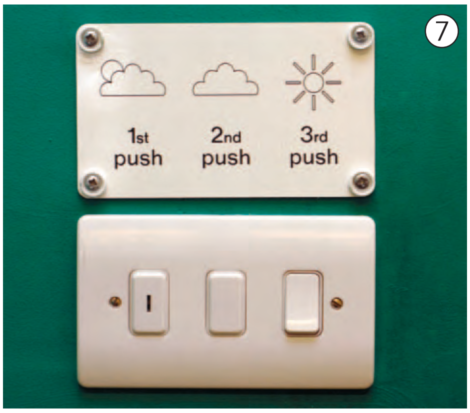
The building occupants have had to experiment to associate each controller with its respective device, then use an indelible marker pen to label the controller.

Note that the ambient light sensor on the far right control has been covered with sticky tape. As this played a role in raising and lowering the blinds, it is assumed that automatic settings did not suit the needs of the occupant, who worked out how to defeat the system.

Usability criteria	Ranking (controller as supplied) Poor Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

These three controllers have icons at the top which suggest they are something to do with windows. Their mounting position is neither close to the items they control nor convenient for the user, but presumably it suited the installer. The users have had to find out what they do and annotate the controllers with a marker pen.

It's clear that the upper switch of each unit can be clicked to the left or the right to open or close the device, or *vice-versa*. But what about lower push button? Does it stop the device opening or closing? Is it a one-shot button for rapid opening and/or closing? Does the upper switch operate something else (such as a blind) when the lower button is pressed? Or is it just a plate to carry the labels for the upper switches? If the lower switches are blank plates, and the annotation relates to the upper switch, then only one of the icons (Velux) provided by the controls manufacturer is related to the image above it. The handwritten labelling may be adding to the confusion rather than resolving it.



Usability criteria	Ranking (controller as supplied) Poor Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

A well-intentioned but ultimately unsuccessful attempt to provide control of classroom lighting using iconography. The idea was to associate an icon with a switch in order to save energy by matching the amount of electric lighting with the prevailing levels of daylight in a classroom. Unfortunately, what was installed fails to meet a number of usability criteria.

The iconography is unclear: the far right icon might be thought to represent full sun when actually it represents full electric light. The symbols look as if they relate to the switches directly beneath them, but they don't. The left hand switch is a key-operated isolator and the centre one is blank. The user control is a single repeat-push switch on the right. Users have to prod this through its three cycles before they achieve a desired lighting condition. There is no off button.

Whatever the cause for the change in specification, the two components – the bank of light switches and the explanatory icons above – no longer map intuitively onto each other. Building users are confused that each icon on the panel does not line up with a switch they can operate. To make matters worse, other versions of this controller installed around the school have switches in the reverse order, so that the push-button is located beneath the partial cloud symbol.

Usability criteria	Ranking (controller as supplied) Poor – Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

This is a very carefully designed, high-quality, multiple-purpose controller. However, it lacks any form of clear labelling or annotation, possibly because the designer believed that the iconography would be self-explanatory. The three numbered buttons and lamps around the central dial fail to explain what they do, and only experiment would reveal their purpose. The central button appears to link to an exit strategy, but it doesn't say how it controls the mechanical or electrical systems serving the room.

The three numbered buttons are fixed settings for electric lighting. The indicator lights beside them are illuminated when the settings are engaged. The button with arrows that completes the circle provides stepless dimming control. The button on the right opens and closes the blinds. The button in the middle allows people to leave before the controller switches all the lights off after a time interval. The ring around it lights up to confirm that exit mode has been engaged; and stays lit after the lights are off so that the switch can be located.

In spite of such careful design, this switch was still confusing occupiers of a school over a year after occupation. While this type of layout may eventually become clear to users, clear explanations for the switches are desirable.

As an exercise in quality injection moulding, the controller is peerless. In terms of the range of control provided, the controller offers plenty of options. From a usability standpoint, the controller is unhelpful and defeats many users. It lacks clear labelling, annotation and explanation.

Usability criteria	Ranking (controller as supplied) Poor – Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

A bank of control switches in a west-facing glazed entrance to a multi-tenanted, three-storey office block. The controls are easy to understand (being based on the familiar light switch), with clear annotation in plain English rather than icons that could confuse people. User understanding would be improved by writing out L/L and H/L as Lower Windows and Upper Windows respectively – there is room for the full terms and it would avoid building users from having to guess.

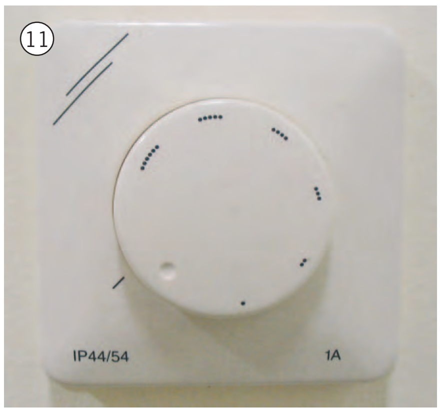
Although the designers may have assumed the entrance was to be occupied by a reception desk, in this instance it is unoccupied. The space is therefore not owned by anyon. This means the controller has to be operated by the site facilities manager unless there is automatic BMS override. The latter was not evident.

This multipurpose controller, in a German building, controls everything and gives good user feedback, although it is not immediately obvious what it does:

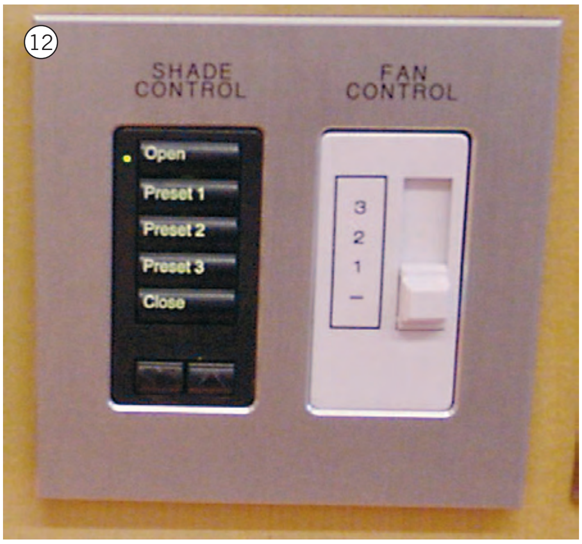
- At the top in the centre are two light switches. The rocker to their left is for temperature regulation rocker (push the top to increase, the bottom to decrease). To their right is an override for the presence detector
- The row of lamps below this show the room temperature status, with frost protection to the left and night setback to the right. (The room is 1°C above the setpoint temperature.)
- Below this, the rocker to the far left opens (up) and closes (down) the window, while the one to the far right opens and closes the blinds. A spare light switch and a blackout switch are located inbetween
- The plastic panel below this is an occupancy sensor, which puts the room into a low-energy state once it is unoccupied
- The large button at the bottom is an emergency stop for the window, for example if something has got trapped in it.

Usability criteria	**Ranking (controller as supplied)** **Poor** **Excellent**
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

Usability criteria	**Ranking (controller as supplied)** **Poor** **Excellent**
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	



An unhelpful rotary dial, marked with a circular dimple, connected to a meeting room ventilation system. The black dots on the dial indicate six settings, but no indication as to what those six settings will provide in terms of comfort conditions. Investigation by a BSRIA researcher revealed that adjustment of the dial leads to immediate sounds of air movement from a ceiling grille, although it is not clear whether this was supplying or extracting air, providing fresh air or recycled air, or whether it was controlling heating and cooling. The only labelling on the device is for technical details (its IP rating and switching capacity), which would only be of interest to the installer.



Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

These controllers at the lectern in a lecture room are well marked, so visiting lecturers will know what they need to do. The lights by the switches also provide feedback on system status. However, it is not immediately clear that the small black buttons at the bottom provide fine control of the window shading.

The fan control to the right is very clear. However, it may not be very efficient because once the fan speed has been set by the lecturer, there seems to be no way of changing it.

Usability criteria	Ranking (controller as supplied) Poor — Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

Another example of a well-designed and intuitive-to-use controller installed in a meeting room. Usable controls are of particular importance in meeting rooms, where control systems for lights, windows and HVAC systems need to accommodate a wide range of uses, settings and occupancy levels.

The controller does all that is required of it: the annotation is clear, the controls intuitive to use (and rightfully robust for the context in which the device is installed), and the controller gives users instant feedback on system operation and status. The left-hand controller has four settings, while the temperature controller shows stepless settings.

A minor criticism is that the user is not aware whether the fan speed is for fresh air, recirculation, or extract. However, this may well be unnecessary in a meeting room if the HVAC has been designed to respond rapidly and intuitively to user demands. In addition, the controller has no facilities for restoring the room to a low-energy state once the occupants have left. In this particular installation, this had been seen as a task for the staff.

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Usability criteria	Ranking (controller as supplied) Poor – Excellent
Clarity of purpose	
Intuitive switching	
Labelling and annotation	
Ease of use	
Indication of system response	
Degree of fine control	

An example of a well-designed window and blind controller, installed in a cellular office occupied by a single person. The controller provides manual controls of motorised blinds and windows.User settings can be overridden by the central building management system, for example when it rains, or to facilitate nighttime ventilation.

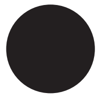
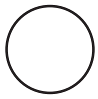
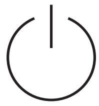
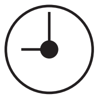
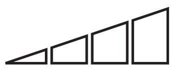
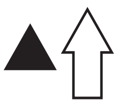
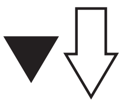
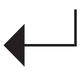
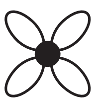
The annotation make clear that the controller operates high level windows, low level windows and window blinds. The control buttons at the bottom have arrows to each side to show that pressing them to the left and right will open or close the named device.

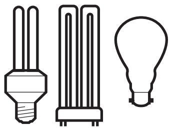
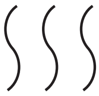
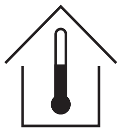
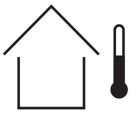
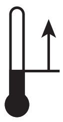
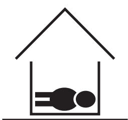
Feedback from the system is immediate, courtesy of the four red lights. Despite the close proximity of the user to the blinds, the occupant may need to know at a glance whether there is any additional window adjustment left, which would be helpful when an open window is partially blocked from view by a blind.

The stepless icon immediately below the red lights is arguably unnecessary. The lights indicate four steps of device positioning, and a user's familiarity with the left and right symbols either side of the button would quickly reveal which direction was associated with open and close. However, if the controller was used in a multiple-occupancy environment (and some distance from the device it is controlling), it may be more necessary to know which direction is for open and close. The more reinforcing information is provided (and the more a given control device can suit a range of contexts and still be useful) the better.

Even this unit is not entirely above criticism: the writing is a bit small and the control buttons fiddly; it does not say which blinds it controls. The 'weather override' annotation looks too much like a title, but it has an important role of telling the user when the BMS has taken control.

BCIA recommended iconography

Icon (based on BS EN 12098-1:1996)	**Description**	**Supporting or alternative annotation**	**Application (To be recorded in O&M manuals and documentation)**	**Indication of action (symbol may be usefully raised to aid the partially sighted)**
	'On' symbol	On (also see 'standby' below)	All applications where on/off control is required	Symbol should be used with off and standby symbols with LCD read-outs, or illuminated icons on a button
	'Off' symbol	Off (also see 'standby' below)	All applications where on/off control is required	Symbol should be used with off and standby symbols with LCD read-outs or as illuminated icons on a button
	'Standby' or automatic symbol (Also used as on/off	Standby or automatic (can also incorporate all the above in a single icon)	All applications where on/off control is required	Symbol should be used with off and standby symbols with LCD read-outs or as illuminated icons on a button, possibly under remote control
	Clock-scheduled automatic control	Timer or clock	All applications where on/off control is required	Symbol should be used with off and standby symbols with LCD read-outs or as illuminated icons
	Continuous, linear adjustment	*Self explanatory*	For controllers where adjustment is truly linear or finely stepped	Should be supported by indication or confirmation of a user action by a change in the display of a scale until the required condition is achieved
	Stepped adjustment	1-3 or 1-5 steps for slider or knob, or 'low', 'medium' and 'high'	Where adjustment is stepped, or where the lack of linear control would be detectable	Should be supported by indication or confirmation of a user action by a change in the display of a scale until the required condition is achieved
	Up or increase (can also be to left and right)	Increase, higher, more	For rocker or push-button control. Not suitable for on/off operation	If control is stepped or continuous, provide indication/confirmation by change in display of a scale or readout when the required condition is achieved
	Down or decrease (can also be to left and right)	Decrease, lower, less	For rocker or push-button control. Not suitable for on/off operation	If control is stepped or continuous, provide indication/confirmation by change in display of a scale or readout when the required condition is achieved
	Return	Keypad return	For controls with LCD screens where control selections have to be entered for a change to occur	LCD or touchpad-type controls should use the same iconography and labelling as simpler, switch-based controls. Over-reliance on icons will not improve user understanding
	Linear increase/ decrease for rotating controller	*Self explanatory*	For rotating controllers where control adjustment is truly linear or finely stepped	If control is stepped or continuous, provide indication/confirmation by change in display of a scale or readout when the required condition is achieved. This bar can be usefully colour-graded
	To show the operation of a fan	A symbol to show the operation of a ventilation system	All applications where on/off control is required	Suitable for use with LCD readouts. Not suitable as a symbol on a push-button or similar without supporting annotation or feedback on status

Icon (based on BS EN 12098-1:1996)	**Description**	**Supporting or alternative annotation**	**Application (To be recorded in O&M manuals and documentation)**	**Indication of action**
	Symbols for electric light (do not use symbols that imply sunlight)	Lighting control	To show the switching or dimming (possibly in stages alongside suitable icons) of electric lighting	Care should be taken with lighting controls to indicate the relationship between user action and change in electric lighting. Words are often more effective than status indicators (see p16)
	Heating/ cooling control	Heating and/or cooling	To signify the control of heating or cooling (with system-specific annotation)	Could be linked to a change in a display until the required condition is achieved. For a user control, icon must be used with an on, off, or stepped controller. In red, it can depict a heating condition
	Cooling control	Cooling	To signify the control of cooling	Action could be linked to a change in colour of scale or other display until the required condition is achieved. In blue, it can depict a cooling condition.
	Temperature control	Increase/ decrease	To signify temperature or functions associated with temperature	Acceptable as an icon on an LCD display. For simpler controls, action could be linked to a change in a display, or supported by a readout or illuminated scale
	Inside temperature	Increase/ decrease	To signify temperature or functions associated with temperature	Acceptable as an icon on an LCD display. For simpler controls, action could be linked to a change in a display, or supported by a readout or illuminated scale
	Outside temperature	Increase/ decrease	To signify outside temperature or functions associated with outside temperature	Acceptable as an icon for access to functions on an LCD display. Usually only suitable for status indication, not for occupant control
	Increase temperature	Increase, higher, more	To signify the operation of a system that is increasing (inside) temperature	Acceptable as an icon on an LCD display. For simpler user controls, action should be linked to a change in colour of the icon, or supported by a display or scale
	Decrease temperature	Decrease, lower, less	To signify the operation of a system that is decreasing (inside) temperature	Acceptable as an icon on an LCD display. For simpler user controls, action should be linked to a change in colour of the icon, or supported by a display or scale
	Occupied mode		To signify that the system under control is working under an occupied condition	Suitable for use with LCD readouts, not as a push-button control without supporting annotation or information
	Standby mode		To signify that the system under control is working in a standby condition	Suitable for use with LCD readouts, not as a push-button control without supporting annotation or information
	Unoccupied mode		To signify that the system under control is set to a mode without occupants	Suitable for use with LCD readouts, not as a push-button control without supporting annotation or information

Checklist for **building designers**

✓ *Tick those that apply and comment*	**The following items should be checked with the controls specification. Tick and make comment if needed. This form is available as a separate download in Word from www.feta.co.uk, www.bsria.co.uk/bookshop and www.usablebuildings.co.uk**
☐	Does the controls specification require the controls supplier(s) and installer(s) to adopt the guidance in *Controls for End Users* published by the Building Controls Industry Association (BCIA)?
☐	Does the controls specification require controls to be accessible to the building's users at the point of need?
☐	Has the specification for user controls been based on evidence from known occupant requirements, such as occupant satisfaction surveys?
☐	Does the brief make clear the anticipated energy savings and occupant satisfaction that should accrue from well-designed, installed and fine-tuned user controls?
☐	Does the controls specification cover the effective, reliable, and economic operation of user controls?
☐	Does the controls specification make clear that the controls solution has to respond to the specific context? (The use of a generic controls solution may not deliver the anticipated end-user benefits.)
☐	Does the specification require the controls to deliver a quick response to the user on what is happening? (Note that some systems respond slowly, such as underfloor heating)
☐	Does the controls specification require the user controls to give instant, tangible feedback? (Such as a click followed up by visual indication of system status, such as a readout or light.)
☐	Does the controls specification require systems to revert to their lowest-energy mode when they are not required. (A general rule is manual on, manual and auto-off.)
☐	Does the controls specification issued to the controls subcontractor contain clauses covering clarity of purpose, intuitive switching, appropriate and clear labelling and annotation, ease of use, indication of system response, and appropriate fine degree of fine control?
☐	Does the controls specification include reasonable tolerances on setpoints? Note that tight control of conditions is often wasteful and inappropriate, and that relaxed settings might be more appropriate, particularly for control of space temperature.
☐	Does the controls specification require the controls supplier(s) and installer(s) to provide the facility and/or space on or beside the controller for explanatory labelling?
☐	Does the controls specification clearly request the use of industry-standard controls symbols as shown in *Controls for End Users* published by the Building Controls Industry Association (BCIA)?
☐	Is the controls specification clear when the the occupant controls are linked to, and communicating over, the building management system communications network?
☐	Does the controls specification make clear the degree to which the occupant controls can control the relevant items of plant in each particular specification?
☐	Does the controls specification make clear the conditions under which a field controller will override settings changed by users on their local control?
☐	Does the controls specification contain a clause requiring override facilities to control the operation of devices during out-of-hours occupation?
☐	Does the controls specification contain provision for requirements for reviewing and improving the performance of user controls and the systems they control, in the first 6-12 months of building occupation? (This would benefit from a fully-funded contract provision that covers whole building fine-tuning, outside of snagging and defects liabilities.)

Designers should also follow the guidance in Section 3 of the Checklist for Controls Installers and Facilities Managers on page 24.

Checklist for **controls manufacturers and suppliers**

✓ Tick those that apply and comment	**The following items should be checked with the controls specification. Tick and make comment if needed. This form is available as a separate download in Word from www.feta.co.uk, www.bsria.co.uk, and www.usablebuildings.co.uk**
☐	Have you adopted the guidance in *Controls for End Users* published by the Building Controls Industry Association (BCIA) in the design of your range of user controls?
☐	Have you made the controls installer or system integrator aware of the BCIA guidance?
☐	Do you have a mechanism by which the design team can define a special (non-catalogue) user controller or labelling system that could be better tailored to specific devices in the building (such as lights and blinds)?
☐	Have the building services designers (consultants and contractors) adopted the BCIA guidance in the controls specification?
☐	Have you made the architect aware of the BCIA guidance, and are you aware of any specific controls requirements made by the architect? (To control windows and blinds, for example.)
☐	Does your guidance to the controls installer include specific advice on the importance of placing a controller in a position suitable for needs of the users, and for the effect of the controller on space conditions?
	Check the following against the designer's controls specification
☐	Are the proposed user controls well-matched to the specific controls task? Do they possess clarity of purpose? (Generic controls products that are not matched to the context may cause problems).
☐	Are the proposed controls simple to understand, use and maintain?
☐	Will generic, off-the-shelf control devices have sufficient functionality, or will they need further attention if what they do in respect of the specific controls task is to be intuitively obvious?
☐	Do your proposed user controls provide enough fine or stepped control?
☐	Does the labelling and annotation provided on your controls possess sufficient detail to be understood by the average building user?
☐	Do your proposed user controls give clear and tangible feedback on system status and operation, such as an audible click and/or display of system status and operation?
	Check the following with the system installer
☐	Has the installer been informed and/or educated on the context-specific requirements where your controls will be used?
☐	Has the installer received guidance on the importance of having context-specific solutions (and avoiding off-the-shelf controls which do not have clear user information) for critical devices like HVAC units, blinds and windows?
☐	Can the installer demonstrate that it has attended training from the BCIA on the importance of providing usable controls?
☐	Has the installer been instructed to provide fine-tuning and user familiarisation during handover and the initial months of building occupation?
☐	When working directly for clients, can the system installer demonstrate that it has involved building users, facilities staff and maintenance staff in the selection of user controls?
☐	Is the installer prepared to provide additional labelling of user controls in the light of early end-user experience, and has this been included in the cost plan?
☐	Have you included provisions for initial training in the use of controls for the building occupants (such as computer-based training on controls operation)?

Checklist for **controls installers and facilities managers**

☐ *Tick those that apply and comment*

The following items should be checked with the controls manufacturer. Tick and make comment if needed. This form is available as a separate download in Word from www.feta.co.uk, www.bsria.co.uk, and www.usablebuildings.co.uk

1. General guidance

- ☐ Have you adopted the guidance in *Controls for End Users* published by the Building Controls Industry Association (BCIA)?
- ☐ Do the user controls possess a level of functionality appropriate to the specific task, as understood by the building's users rather than design specialists?
- ☐ Are the architects and site contractors aware of the need to locate the user controllers close to the devices they control or where the users want to access them?
- ☐ Have you provided the right annotation or enough labelling to ensure that users will know precisely how to operate the controls?

2. During commissioning

- ☐ Do all user controls in the building have suitable annotations or labels?
- ☐ Is the facilities manager fully aware of the purpose of each controller?
- ☐ Do the operation and maintenance documents explain the purpose of the controls, and ways to adjust them within the limits set by the design?
- ☐ Do the user controls possess a level of functionality appropriate to the specific task, as understood by the building's users rather than design specialists?

3. During ongoing occupation (some of the following may require extra provisions in the contract)

- ☐ Will you solicit feedback from building users on usability, and propose any remedial actions to improve the as-installed controls?
- ☐ Will you check whether any user controls need fine-tuning, particularly to match changes in main plant operation? (This should be separate from snagging and defects remediation)
- ☐ Will you check whether any user control presets need resetting to balance user satisfaction and energy efficiency objectives/targets?
- ☐ Will you check to ensure that user controls are not defaulting systems to on, wasting energy and annoying the occupants?
- ☐ Will you check to ensure that user controls are not being unnecessarily overridden by central controls in a way that conflicts with the original design intent and controls specification?
- ☐ Are the setpoints in user controls suitably flexible to allow users to change their comfort conditions without causing disruption to central controls or wasting energy?
- ☐ Can building occupants use their local controls to achieve timely, effective and lasting changes to their comfort conditions? (Note: systems must be commissioned to operate within their design parameters

The usability and performance of user controls can be improved by adopting a long term (12 months) separately-funded controls fine-tuning agreement with the buildIng owner. This would not necessarily include maintenance, but would include staff training and additional explanatory labelling for user controls.

Further reading

Dale H C A, Crawshaw, C M
Ergonomic Aspects of Heating Controls
Building Services Engineering Research & Technology 4(1) 22-25 (1983)

Mill P
Office Ecology: Intelligent Boundaries for Productivity in the '90s
Designing for Environmental Quality 1990, Conference preprint

Chartered Institution of Building Services Engineers
Applications Manual : Automatic Controls, page 3 (1985)

Donald I
Putting the Workers in their Place: Environmental, Organisational and Contributions to the Office Experience
Designing for Environmental Quality 1989, Conference proceedings

Cooper A
The Inmates are Running the Asylum, Samms/Macmillan, 1999

Cooper I
Environmental quality: responding to a new agenda, signing for Environmental quality 1989, Conference proceedings.

Nielsen J,
Usability Engineering, Academic Press, 1993

Nielsen J
Designing Web Usability, New Riders Publishing, 2000

Norman D
The Design of Everyday Things, New York: Basic Books, 1988

Norman D
The Invisible Computer, MIT Press, 1998

Tenner E
Why Things Bite Back - New Technology and the Revenge Effect.
4th Estate, London 1996

Winograd T (ed)
Bringing Design to Software, ACM Press, 1996

Useful websites

Usable Buildings: www.usablebuildings.co.uk
Alan Cooper: www.cooper.com
System Concepts: www.system-concepts.com

BCIA

Building Controls Industry Association