Folk Labeling: Insights on Improving Usability and Saving Energy Gleaned from After-Market Graffiti on Common Appliances

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ABSTRACT

The after-market labeling of a device by its users often indicates problematic usability, which can affect the device's energy consumption. For example, when people find a lighting control panel difficult to use, they often write instructions on a piece of paper and affix it nearby as a reminder to themselves and to help others.

We collected over a hundred examples of these "folk labels" from commercial and residential buildings through an online contest inviting people to upload photos of folk label examples, informal solicitation of colleagues, online searches, and personal observation. Some folk labels offered guidance or reminders (e.g., turn off light before fan on a projector); some provided specific instructions for multi-function controls or addressed problems identifying orientation or direction (right/left, on/off). We categorized these folk labels (e.g., by location, subject, form, etc.), and analyzed them according to usability guidelines and heuristics[1]. In addition, we evaluated their potential impact on energy consumption. We found that most folk labels indicated usability issues in three areas: visibility of available options, natural mappings, and consistency. For example, one light switch looked like a simple toggle ON-OFF control, but actually could control various dimming options (violated "visibility of available options" principle). One would naturally turn the light on full power if one did not know how to use the dimming capability. We discovered that folk labeling provides a simple means of identifying usability problems.

Background

The term "folk" has been applied to folk theories and models in various disciplines, including psychology, economics, and science. These folk models and theories describe a common sense model about how something works, as opposed to the "correct" theory defined by experts. By its very nature, a folk model has "a partial and situational ad hoc quality, a lack of global systematicity" (Keesing 1985). Some researchers prefer other terms such as ethnotheory, since by definition folk connotes a lack of sophistication.

The study of folk models includes how people construct mental models (Collins and Gentner 1995). Our language is full of metaphor and analogy (Lakoff & Johnson, 1980); these analogies in turn help create mental models, which are vital to how we understand the world and predict what will happen in new situations.

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[1] Nielsen uses the term heuristic to mean a rule of thumb or general principle developed by experience to guide usability design; Nielsen's heuristics are often used in web interface design (Nielsen 1993).

With respect to energy and behavior research, Kempton described the role of folk measurement models and folk models of thermostats three decades ago (Kempton et al, 1982, Kempton & Montgomery 1982). On the one hand, Kempton argues that folk measurement models are counterproductive, that it would be better if people's beliefs about energy consumption were closer to expert models (e.g., visibility: insulating one's attic saves more energy than turning off a light, but turning off a light is more visible and tangible). With respect to Kempton's two folk models of thermostats (feedback and valve[2]), he suggests that if people converted from the valve theory to the feedback theory (which is closer to expert theory), they may save management effort (e.g., less need to change the settings so often). On the other hand, the valve theory encourages conservation (e.g., less energy use from lower temperature setting).

Mental models are also used in industrial design (Norman 2002) and web design (Nielsen 1993) to discuss usability issues. When people have difficulty using a device, often one can determine a dichotomy between their mental model and the mental model of the expert, in this case the manufacturer or designer. The user interface is thus a natural place to study these mental models.

One of the authors (Granderson) in her work with lighting interfaces noticed labels on some light switches, and thus started our collection of "folk labels". We use the term folk labels to include handwritten, typed or otherwise after-market labels or signs in communal areas, often affixed to devices and providing direction. This term captures the sense of observing what is in the field—as Kempton, Wilhite, and others before us—in order to analyze the discrepancies between the expert mental model and the common mental models.

Among the other factors, lack of standardization in control interfaces can play an important role in making devices less usable and can contribute to confusion and inappropriate use. Previous work by Nordman led to a new IEEE standard that made power management controls more consistent and intuitive (IEEE 2004; Nordman, Meier, and Aumann 2002). However, in the last few years many new lighting and heating/cooling controls have been introduced into the market without proper standardization (Nordman et al. 2010).

Other work in thermostat usability (Meier et al. 2011; Perry et al. 2011; Pritoni, Meier, and Perry 2011) helped create our hypothesis: many folk labels help people properly use devices that are not intuitive or easy to understand and thus folk labeling can identify usability issues. Analyzing these folk labels can act as an inexpensive usability test, allowing us to discover devices with poor usability related to their design as well as to develop suggestions for how these devices could be improved. We were particularly interested in the cases in which the usability issues affected energy consumption.

Methodology/Research Design

Our collection began in an ad-hoc manner. We began taking photographs of folk labels as we came across them in everyday work and in our travels; additionally, Gari Kloss made several folk labeling expeditions through buildings at LBNL. Additionally context and folk stories were gathered when possible. We also searched the web for images. Then we actively solicited photographs and stories in several venues: advertising a contest on a website

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[2] The valve theory refers to the belief that the thermostat works like a valve or gas pedal—the higher you set the temperature, the hotter the output of the furnace, and the quicker the house heats up. The feedback theory is that the furnace cycles on and off to achieve the temperature setpoint.

(http://depts.washington.edu/sccl/research/energy/) and soliciting through two editorials in Home Energy Magazine (Meier 2012) and an ECEEE web blog (Meier 2012).

In all we collected over 100 labels. We chose 50 to analyze, focusing on labels that were on devices, but keeping a few examples of other types of labels such as for safety, location-related, or commentary. Of the 50, about half (23) were related to lighting controls and ten related to thermostats. Other devices included an autoclave, copy machines, door handles, audiovisual equipment, drink dispensers, vendacard machines, toilets, and an elevator. By no mean we consider this to be a representative sample of the labels that can be found on all energy devices. Nevertheless they represent interesting cases from which more general conclusions can be drawn. Six examples of these labels are presented in the next few paragraphs and analyzed in the following sections. While collecting photographs, a selection of guidelines from the usability literature was compiled (Shneiderman and Plaisant 2009; Nielsen and Molich 1990; Nielsen 1993; Norman 2002; Polson and Lewis 1990; Bordass, Leaman, and Bunn 2007) and these heuristics were used to analyze the folk labels. The 12 heuristics developed are shown in Table 1.

### Table 1. A compilation of guidelines for more usable interfaces

	Heuristic	Description
1	Feedback	Offer informative and timely feedback
2	Visibility	Make system status visible, Make it easy to see possible actions
3	Match between system and the real world	Use both knowledge in the world and head
4	User control and freedom	Make users feel they are in control; control located close to point of need
5	Consistency and standards	Strive for consistency, When all else fails, standardize.
6	Easy to understand & use	Tolerate at most one hard-to-understand action; good defaults
7	Recognition rather than recall	Minimize short-term memory load-- Take into account occasional use, Get the mappings right
8	Flexibility and efficiency of use	Cater to universal usability
9	Aesthetic design Simplicity of interface	Offer few alternatives. Require as few choices as possible.
10	Prevent errors	Design for error
11	Permit easy reversal of actions	Help recognize, diagnose, & recover from errors
12	Informative help	Provide help and documentation

Folk Label Examples

Figure 1 shows a folk label for a lighting control for an open plan office "collaboratory" from a campus building at UC Berkeley. The two by four foot lighting fixtures are three-lamp/two ballast fluorescent lamp systems, controlled in three zones. The button panel provides control over each zone as well as stepped dimming (e.g., ballast 1-one lamp, ballast 2-two lamps, ballast 1+2-all three lamps). This is a clear example of a usability problem; indeed the mapping of the buttons to the floor plan is not obvious and creates confusion to the user. Also the dimming option is not visible; thus the building manager thought that a clarifying label was needed. This lighting control actually requires a label in order for a person to understand which lights to turn on and to what level.

Regarding energy consumption, if the dimming controls are not clearly defined, it is difficult to expect any energy savings. In practice, these lighting controls are typically only used on weekends and at night, since the lights are controlled centrally on a weekday schedule. Nonetheless, one researcher discovered that the lights were almost never used in a dimmed capacity, and when the lights were turned on with this controller at night, they were rarely turned off and remained on all night (Krioukov et al. 2011).

Figure 1. Left: folk label that describes zone lighting and stepped dimming. Right: the actual lighting control panel. (Photos by Peffer)
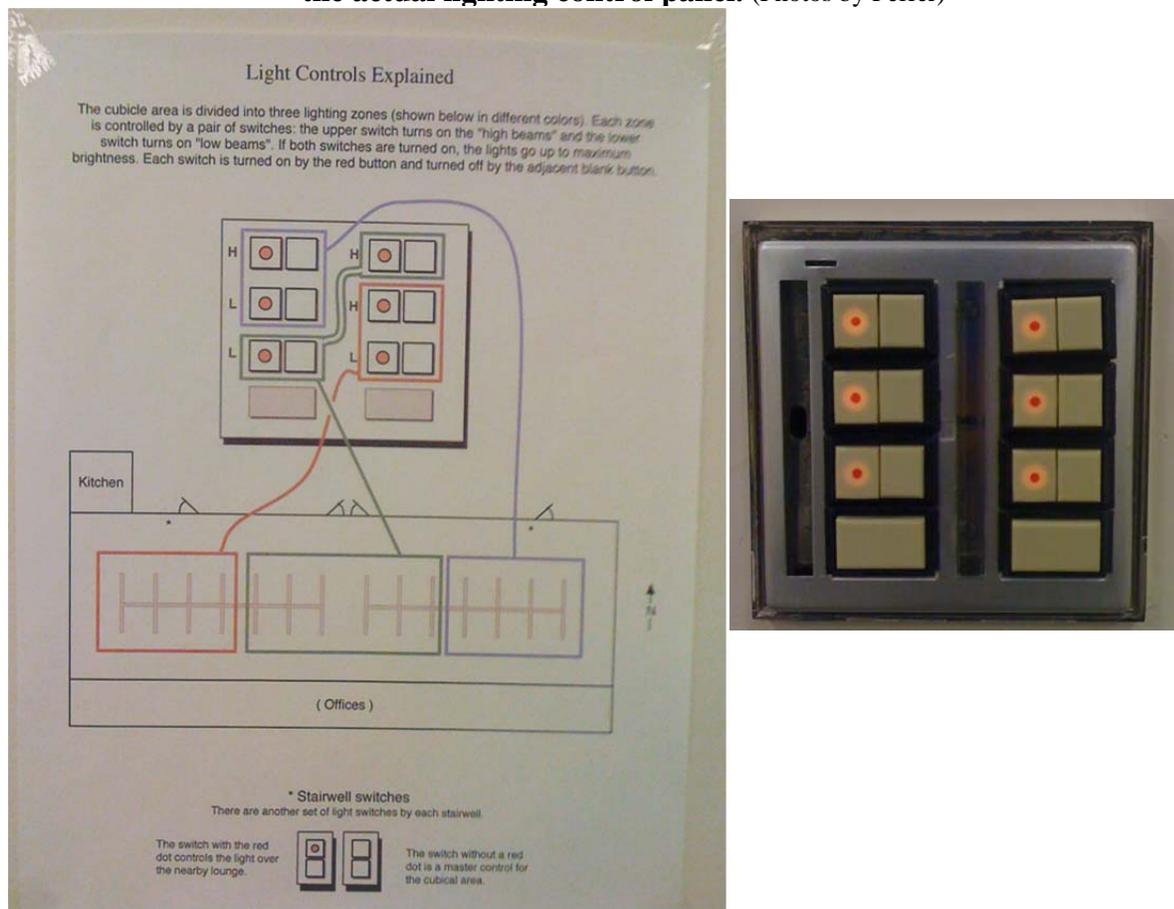
Another example of folk labeling on a lighting control is in Figure 2. This label was found on the web on a blog of a usability professional. The author argues: "At first I thought it was some kind of silly "engineer" joke. But the light switch functions as stated are for real. Does it win the award for the most confusing light switch? I bet there are other ones out there that are equally complex to use." This apparently traditional-looking switch has multiple functions depending on number, intensity and duration of touch. These modes of interaction are not standardized across other devices and possibly not even across devices of the same manufacturer. Also a very small button, almost impossible to notice, is added in the middle of the switch to "save" the current settings. We have no information on the origin of the label, if it was produced as add-on by the manufacturer or added by users or facility managers. We found other similar examples with lighting controls.

Figure 2. Folk label on a dimming light switch at Sun Labs.

(http://lawsofsimplicity.com/2007/06/10/how-many-engineers-does-it-take-to-turn-on-a-light-bulb/)
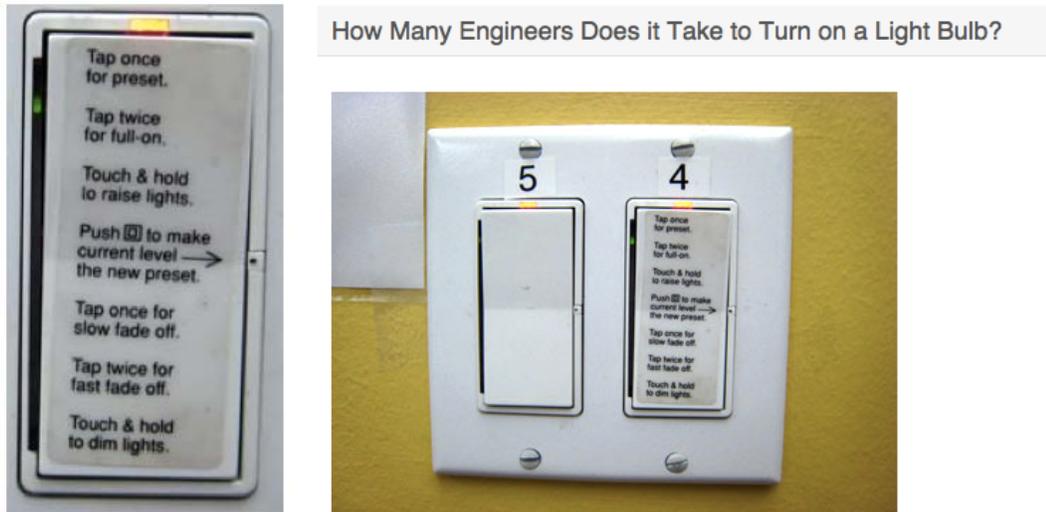
For thermostats, one example of folk labeling was the instructional label in Figure 3 on a supposedly simple, non-programmable thermostat in a hotel. It says: "For heat, move the switch to heat. For A/C switch to cool. Use up/down arrows for desired temperature." One might think that the interface was self-explanatory (and thus usable). But the addition of the typed note on the thermostat indicates that enough people were confused by the operation of the thermostat to necessitate the label. In this case, it is difficult to make a judgment on usability and energy consumption; the label only indicates the hotel management's concern for the customers' comfort and ability to operate the thermostat.

Figure 3. Folk label on a hotel thermostat

(http://superfantastic.blogs.com/weblog/random/)

Another example of a folk label on a thermostat is in a multi-guestroom facility (Figure 4). There are clearly two different sets of notes on this device. This example shows another common feature of folk labels: its additive nature. Quite often, one person will provide a label and others will add another label presumably to augment or clarify the message. In this case, there is a typed notice about leaving the thermostat at 72F, and then a handwritten note adding more emphasis and reasoning behind the request. Bret Curry writes, "The older dwelling comprises a series of existing residential dwellings converted into a multi guestroom facility. The facility is a non-profit entity provided so families can stay near and support a hospitalized child who is undergoing treatment or hospitalization. Their intentions were noble, but created a comfort, humidity and excessive consumption challenge." This is a case where the folk label could potentially create greater energy consumption. With an older system like this, it is difficult to know whether this is a usability problem or just a deeper problem with the HVAC system in an older building not meant to function in a multi-zone fashion.

Figure 4. Folk label on a communal thermostat. (Photo by Bret Curry).
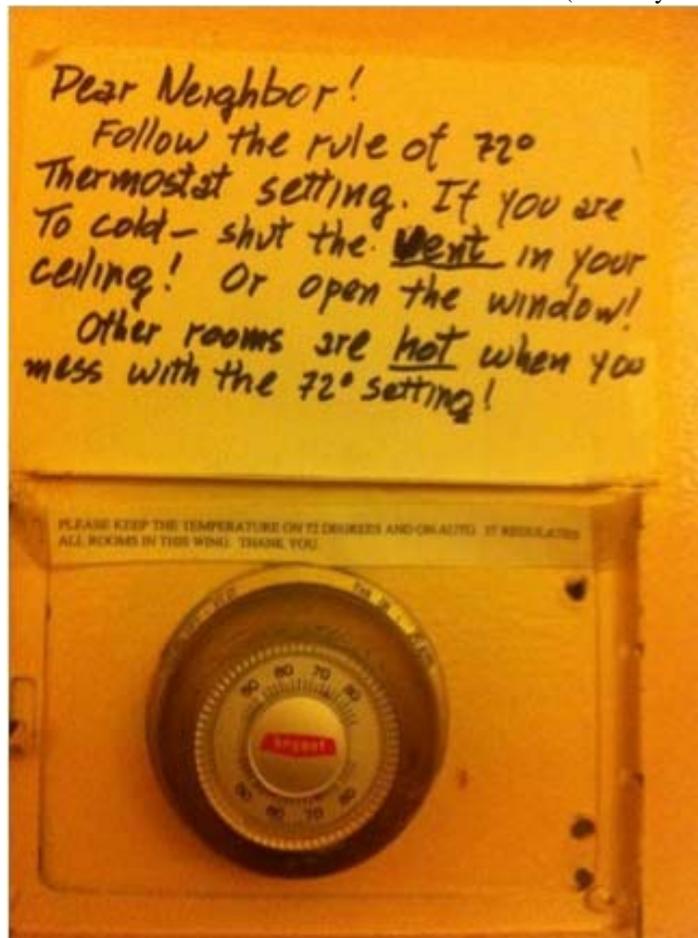
In large commercial buildings the room thermostat can be the final terminal/sensor of a more complex building management system. The photo in Figure 5 was taken in a laboratory at UC Davis. The verbose label, which looks more like an instruction manual, explains in detail the interaction between the central system and the local control. The label reads, "User control of Siemens room sensor with setpoint control and night override button." We found that it was an

attempt of the facility manager to address the complaints about thermal comfort in the room and to improve efficiency of the system. The label was written in technical language (e.g., setpoint, override) and a small font. After some time somebody added with a marker, "READ". Both labels disappeared after two months. The control clearly presents some usability issues: first of all the temperature lever is hidden under a cover. Further, the local temperature range is limited by the master system, and there is a night saving option. It is clearly difficult to convey all this information in a control interface, and the instruction sheet was meant to do it. Unfortunately this "technical-folk" sheet was not successful and was removed.

Figure 5. Folk label on a lab sensor/thermostat

Other common labels were for motion-sensing or occupancy-sensing controls, especially for bathroom lights and toilets. Visibility may play a role; if people do not know the device is automatically controlled, they may not understand how to interact with it. One label instructed the person to wave at the toilet in order for it to flush. Other labels informed people of the motion-sensor (Figure 6) or requested that the sensor not be switched off. In general, occupancy-sensing switches do not have a consistent or standard icon that indicates this type of control.

Figure 6. Folk label notifying of the presence of a motion-sensor
(Photo by Granderson)

Analysis

Using heuristics listed in Table 1 these examples were categorized. Lighting controls in general provide instant *feedback*, as opposed to heating and cooling controls. Therefore a person could push buttons at random and learn pretty quickly what controls what. Thus, traditional lighting systems support the heuristic *Match between system and real world.*

However, the interface in Figure 1 violates the principle of *visibility*: the lighting panel does not indicate the status of the system (e.g., lights on or off) nor what each button does.

In Figure 2 the main usability heuristic violated is *visibility*: make all possible functions visible. If this switch were not labeled, a person would not know that there was any dimming capability or preset capability. Unlike the previous example, this interface does not provide an adequate *match between the system and real world* in that it looks like a typical toggle switch, which is not touch sensitive. One might not learn about how this switch controls lights by merely trying it out.

Thermostat controls as in Figure 3, 4, 5 have less timely *feedback*, since the thermal effect is always delayed. The system status in Figure 5 is unknown, since there is no display and the system might be controlled by the central energy management system violating the *visibility* heuristic. The label, indeed, tries and explains the complex interaction between the two systems, but it was unsuccessful and then it was removed.

Another usability heuristic refers to reducing *memory load* by using mappings; in Figure 1 there is no natural mapping between the layout of the eight switches and the three zones, nor is there any differentiation between low light level and high level. Also the switch in Figure 2 requires an intense memory load to recollect all the possible interactions with the device.

There is currently no *standard* on lighting controls and switches. In addition we can expect the coming years to see increasing complexity in controls, with more use of sensors for daylight and occupancy, price responsiveness, integration with controls for different end uses, and with solid state lighting, even color control (Nordman et al. 2010). We found evidence of this lack of *consistency* in our exploration of folk labels.

Error prevention is almost never taken into account in these controls. In Figure 1, 3 and 4 the labels show practical instruction to avoid mistakes.

Finally, the only example that provided *help* or documentation was Figure 5. A summary of the results of these heuristics applied to the examples is presented in Table 2.

Table 2. Heuristics applied to label examples

	Heuristic	Example (Figure)					
		1	**2**	**3**	**4**	**5**	**6**
1	Feedback	ok	ok	no*	no*	no*	ok
2	Visibility	no*	no*	ok	ok	no*	no*
3	Match between system and the real world	ok	no*	ok	ok	no*	no*
4	User control and freedom	ok	no*	ok	ok	no*	no*
5	Consistency and standards	no*	no*	ok	ok	no*	no*
6	Easy to understand & use	no*	no*	ok	ok	no*	ok
7	Recognition rather than recall	no *	no *	ok	ok	no *	ok
8	Flexibility and efficiency of use	ok	no*	ok	ok	no*	no*
9	Aesthetic design Simplicity of interface	ok	no*	ok	ok	no*	ok
10	Prevent errors	no*	no*	no*	no*	no*	no*
11	Permit easy reversal of actions	ok	no*	ok	ok	no*	no*
12	Informative help	no*	no*	no*	no*	yes	no*

no* :problems were detected applying the heuristic to the device

ok: the device performed ok under the heuristic

Discussion

We categorized all 50 folk labels on the subject or nature matter of the label (Table 3), such as directionality (e.g., open/closed), assignment (e.g., left switch operates general lighting), multi-step operations (e.g., first turn off the light, then the fan on the projector), guidance (e.g., advice, reminders), safety (e.g., glow in the dark arrows), location/wayfinding, and commentary. Nearly half of the labels described how to use a device (*instructions for operation*); a quarter detailed *assignment*, or what switch controls what area. Many provided *preferred/optimal settings*. A few merely provided *information* or *guidance*.

Table 3. Themes found in the folk labels.

Subject description	Example
Instructions for operation	How to use this device
Actuation, Orientation/directionality of control	Right/left, up/down, open/close, on/off
Multifunction operations and multi-step operations	Projector: First turn off light, then fan. (Common on dimming switches, thermostats, copy machines, faxes, shredders, lockers)
Assignment	What device does a switch or control operate? E.g., (Spatial) Left switch operates lighting on the left;
Preferred/Optimal settings	Leave light on during office hours to keep fan running, reduce temperature to 60F when leaving and adjust to 68F upon return
Information	Not functional, motion sensor in bathroom
Guidance	
Advice	Occupancy sensor will turn light off
Encourage behavior/Reminders	Turn off light when leaving room
Motivation	Please compost, recycle
Emergency/Safety	Glow in the dark arrows in bathrooms, skeleton as safety reminder
Location/way-finding/homing	Restrooms down the hall, men's room next floor; enter next door—this door blocked; please return stapler to desk, remote control to table
Commentary, humor	"No clue" label on light switch; "Use your shirt" on broken towel dispenser.

For instance, the label in Figure 1 provides *instructions* and *assignment*: which button controlled which zone or area, and "how much" light was controlled. Figure 2 shows *instructions for multipurpose function*. Another label in our collection, not shown here, is categorized as instructions for *multistep operation*. The label states:

"For heat and cool:
-set top switch to auto
-set bottom switch to HEAT or COOL
-set thermostat to 70
-turn timer to number of hours needed
-system shuts automatically, leave switches as above"

Usability and mental model user/designer. Of our small sample of folk labels, we found over half (28) were related to the poor usability of the device. Of those related to usability, we found several folk labels on devices that do not necessarily improve usability. For example, for one pair of light switches, one was labeled "on" and the other "off", but what do these control and what happens if both are switched? Some folk labels were attempting to simply translate one "language" to another. For instance, several instructional labels were translating in practical terms the intent of the designers. Of the folk labels on devices that appeared to point to poor usability, some of the heuristics were easily applicable to the interface usability, especially *visibility*, *match between system and real world*, *feedback*, *recognition not recall*, *consistency*, and *helpful information*. The violation of the heuristics showed that designers were not successful in understanding the users' mental models (nor making their mental model accessible to the users). However the problem is not limited to the users and designers.

The majority of the folk labels not related to the usability of the device acted as reminders or indicated a preferred or optimal setting. Often the label was not clear or lacked explanation, e.g., what does the switch actually control? Why "please leave on"?—what happens if the switch is turned off? Sometimes an added explanation was helpful (e.g., "Don't turn off, it goes into power save" connected to copy machine, or "Keep light on during office hours to keep the fan on" in a bathroom), but sometimes was rather confusing (e.g., on a toilet in Turkey, "Please help us save water. Flush twice.")

Energy implications of poor usability. We found that about a third of the folk labels had clear implications on energy or resource consumption, about half of the folk labels did not appear to have implications on energy consumption (e.g., light control assignment, instructions, location), and the rest were unclear. Of those labels that clearly affected energy consumption, about half acted as reminders, suggested preferred settings, or otherwise encouraged energy saving behavior (e.g., please close door to save energy, close windows before turning on heat, turn off lights when leaving, turn thermostat down to 60F when leaving). Two of the labels suggested a setting that might use more energy ("Don't turn off; it goes into power save" on a copier and "Keep light on during office hours to keep the fan on" for a bathroom). These suggest an opportunity to explore the reasons for this increase in energy—e.g., convenience or comfort— and perhaps find a work-around or revisit the original control design. For a subset of these folk labels, usability of the device would affect energy consumption, especially on lighting controls

(especially dimming) and thermostats. If the lighting control does not clearly indicate that the lights may be dimmed, most users will probably not dim the lights, and thus save energy.

Common themes. We found several common themes. In commercial buildings, in general people are not incentivized to conserve nor to learn how to use controls. On many devices, some of the least important information is most clearly displayed (e.g., name of the manufacturer). *Lighting controls* are growing increasingly complicated, with functions such as dimming and saving a setting, and multiple types of lighting controls "ganged" together with no clear mapping. The fact that there are no standards among the manufacturers doesn't help. *Thermostats*: even the easiest to use need labels in room of short occupancy permanence (e.g., hotel rooms, conference rooms). *Motion sensors:* since there is no standard icon or symbol to indicate the presence of an occupancy sensor as part of the control, these can be annoying and confusing since they are not visible.

We suggest that controls are going to grow increasingly more complicated. The conventional light switch is disappearing in the commercial sector and the same trend will occur in the residential sector as well. Usability can be improved in the long term by standardizing elements, symbols, and interaction methods within different interfaces.

Future Work

We plan to continue to collect, categorize, and analyze these labels. We recognize that much more research is needed to connect poor usability and energy consumption. Our goal is to find cases where we can collect quantitative data on energy consumption based on the device and folk label.

Conclusion

Folk labels can provide a simple indicator of poor usability issues on devices or controls, some of which have energy implications. We collected over 100 after-market labels—folk labels on various devices and locations mostly in commercial buildings, but in some houses as well. The subjects fell predominantly in the category of instructions how to operate the device (e.g., lighting, printers, copiers, thermostats), but also preferred settings (e.g., keep light on during office hours to keep the fan on). Especially with respect to lighting controls, another common subject matter was assignment: e.g., the left switch controls the east zone. We also found folk labels in other categories, such as commentary or encouraging certain behavior (e.g., recycling, composting). We did find that many folk labels indicated poor usability of the device, whether door handle, audio-visual equipment, copier, dimmer light switch, or thermostat. Of these, the lighting controls (especially dimming switches) indicated that poor usability could lead to increased energy consumption. Two of the labels indicated a setting that may increase energy consumption (e.g., copier, bathroom fan); these present an opportunity to determine if reduced energy consumption is possible or a redesign of controls is necessary to achieve the desired condition.

While many folk labels attempted to clearly explain the operation of a poor interface, we found that a folk label does not necessarily improve the usability of a device. We found many usability heuristics helpful in pinpointing the nature of the usability violation.

Controls will only continue to grow more complicated. While folk labels can provide a crude indicator of usability problems, further research is required to quantify these issues and to more concretely show the potential energy consumption implications.

References

Bordass, Bill, Adrian Leaman, and Roderic Bunn. 2007. Controls for End Users a guide for good design and implementation. Reading, Berkshire, U.K.

Collins, Allan, and Dedre Gentner. 1995. How People Constuct Mental Models. In *Cultural Models in Language and Thought*, edited by D. C. H. a. N. Quinn. New York: Cambridge University Press.

IEEE. 2004. IEEE 1621, Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments. New York: Institute of Electrical and Electronic Engineers (IEEE).

Keesing, Roger. 1985. Models, "Folk" and Cultural. In *Cultural Models in Language and Thought*, edited by D. C. H. a. N. Quinn.

Krioukov, Andrew, Stephen Dawson-Haggerty, Linda Lee, Omar Rehmane, and David Culler. 2011. A Living Laboratory Study in Personalized Automated Lighting Controls. In *BuildSys'11*. Seattle, WA: ACM.

Meier, Alan. *Deconstructing Folk Labels for Energy Savings — ECEEE* 2012. Available from http://www.eceee.org/columnists/Alan_Meier/deconstructing-folk-labels.

———. 2012. Editorial: Folk Labels and Home Energy. *Home Energy* April.

Meier, Alan K, Cecilia Aragon, Therese Peffer, Daniel Perry, and Marco Pritoni. 2011. Usability of residential thermostats: Preliminary investigations. *Building and Environment* 46 (10):1891-1898.

Nielsen, J., and R. Molich. 1990. Heuristic evaluation of user interfaces. In *CHI'90 Conference*. Seattle, WA: ACM.

Nielsen, Jakob. 1993. *Usability Engineering*. San Francisco: Morgan Kaufmann.

Nordman, Bruce, Jessica Granderson, Alan Meier, and (Lawrence Berkeley National Laboratory). 2010. Lighting Control User Interface Standards, PIER Report. Sacramento: California Energy Commission (CEC).

Nordman, Bruce, Alan Meier, and Don Aumann. 2002. Fixing the power management controls problem. *2002 ACEEE Summer Study on Energy Efficiency in Buildings* 7:167-178.

Norman, Donald. 2002. *The Design of Everyday Things*. New York: Basic Books.

Perry, Daniel, Cecilia Aragon, Alan Meier, Therese Peffer, and Marco Pritoni. 2011. Making Energy Savings Easier: Usability Metrics for Thermostats. *Journal of Usability Studies* 6 (4):226-244.

Polson, P.G., and C.H. Lewis. 1990. Theory-based design for easily learned interfaces *Human-Computer Interaction* 5:191-220.

Pritoni, Marco, Alan Meier, and Daniel Perry. 2011. Human Factors in Climate Controls for Small Commercial Buildings. Johnson Controls.

Shneiderman, B., and C. Plaisant. 2009. *Designing the user interface: strategies for effective human-computer-interaction*. 5th ed: Addison Wesley.