COLLEGE OF SOCIAL SCIENCES
public policy center
UNIVERSITY OF HAWAI'I AT MĀNOA

Sustainable Saunders Survey

Preliminary Overview, June 2007

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Many aspects of modern workplaces could be more sustainable, and virtually any effort to improve requires an understanding of the interaction between available technology and human preferences and behaviors. Under the heading of the "Sustainable Saunders Initiative", Saunders Hall, on the UH Manoa campus has been designated as a tangible focal point for implementing innovative technology and human behavior programs to reduce the ecological footprint of the university.

As part of the Sustainable Saunders initiative, The Social Sciences Public Policy Center administered a survey of all the Saunders occupants in Spring 2007. Questions were developed in cooperation with the Sustainable Saunders HUB student group, and the web portion of the survey was constructed by the College of Social Sciences Information Technology Office.

The survey requested self-reports of sustainability-related behaviors, such as recycling, overnight computer shutdown, stairwell use, and transportation to and from the workplace. These behaviors might seem trivial in isolation, but they add up to substantial environmental consequences when aggregated across a building full of people. This Preliminary Overview presents detailed estimates of the environmental consequences for the following elements, together with brief suggestions about potential remedies.

- Travel between work and home
- Lighting preferences
- Air conditioning and ventilation preferences
- Beverage container recycling
- Elevator use
- Overnight computer equipment power use

When all was said and done, we achieved a 70% response rate by employing Dillman's (2007) "tailored design" approach to survey administration.[1] This response rate is even better than

[1] We constructed multiple stages of carefully constructed messages to potential respondents and presented mixed modes of contact (both paper and web-based questionnaires were delivered. Pre-notifications were delivered by paper to mailboxes. Reminders were delivered by email). The best available contact list for the building

typical rates reported by Dillman, and is much higher than the 10% to 30% common for web or paper surveys used in isolation. The high response rate is also testament to the concern about the workplace and support for sustainability felt by the people who work in Saunders Hall.

Getting To Work

Over 90% of building occupants travel by automobile for at least some of their commute between work and home. Combining the number of days each survey respondent comes to campus each week, with the number of miles they drive and the estimated mileage of the car the respondents reported, it appears that Saunders occupants who arrive in their own motorized vehicle use about 486 gallons of gasoline getting between home and work each week. This estimate includes motorcycle transport, but excludes the gas consumed by buses, and the gas saved through carpooling, both of which are very difficult to estimate. Table 1 illustrates the calculations for the estimate.

Table 1: Transportation Calculations

gallons per week for any one driver was calculated as:

number of trips driving to and from the office each week*	×	number of miles from home	÷	miles per gallon for driver's vehicle	=	gallons per week used by driver to get to and from work in Saunders

total gasoline consumption for the building can be calculated as:

gallons per week used by drivers to get to and from work in Saunders (survey average)	×	number of Saunders occupants driving to work (estimated from survey proportion)	=	total Saunders gas consumption per week
3.00		161		483 gallons

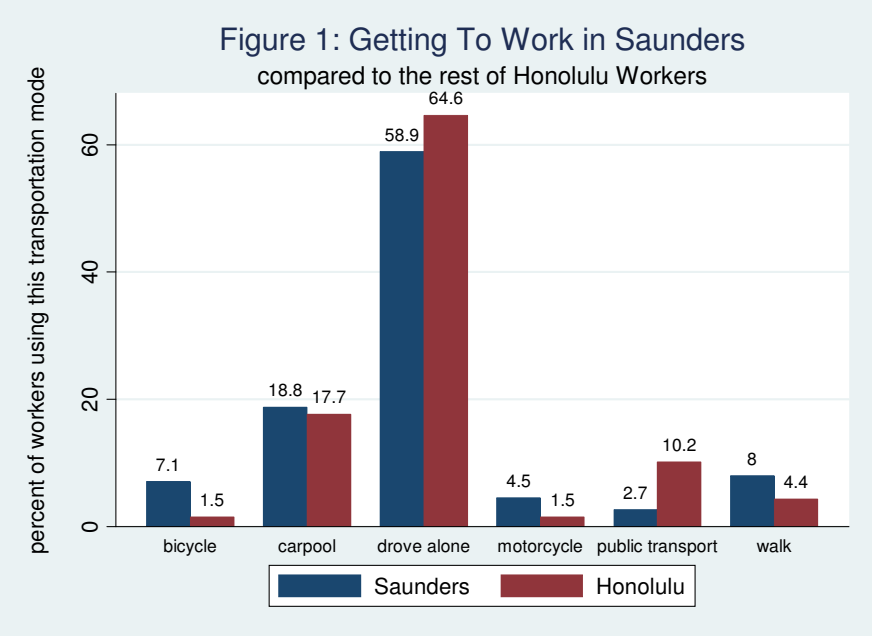
* includes an adjustment for occupants reporting that they drive only a portion of the time, and take another transportation mode the remainder of the time.

occupants was assembled by CSS IT - it contained office location and email contacts for 175 faculty, staff, and students working in Saunders Hall. The list was cross-checked with the office assignment list maintained by the CSS Dean's office.

To put this in a global warming perspective, this gasoline consumption puts about 9,500 pounds of carbon dioxide into the atmosphere[2] each week. If the University purchased carbon offsets to make the transportation of its Saunders occupants carbon-neutral, it would cost between $26 and $130 per week, based on the wide range of carbon offset prices[3] available in the marketplace (Kollmuss & Bowell 2007).

The calculations above help illustrate the many points of attack possible in reducing the greenhouse gas emissions involved in getting people to and from work in Saunders. Many approaches could be fostered by changes in public policy, though the effectiveness of any of them would need to be evaluated. Potential approaches include:

1. Reduce the number of people driving (encourage theBus, walking, or bicycles, discourage driving). Significant numbers of building occupants arrive by alternative means, and even those arriving by car are often carpooling. Figure 1 illustrates the proportion of Saunders building respondents traveling between home and work, for each major transport mode. Figure 1 also illustrates the transportation profile for all workers in Honolulu, based on the U.S. Federal Highway Administration's 2005 American Community Survey.[4]

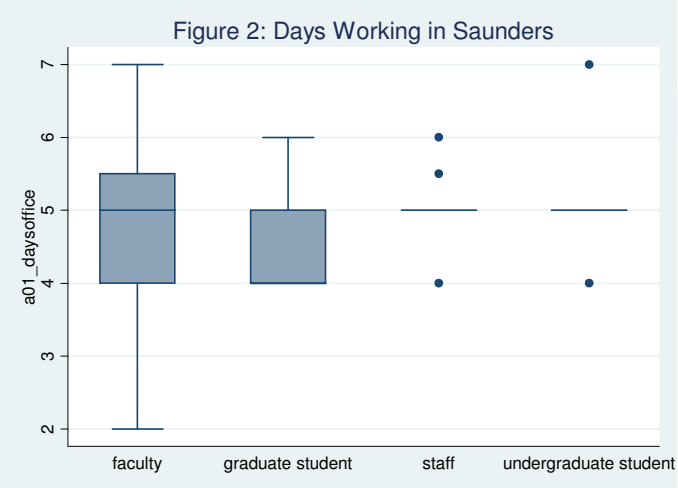


[2] Based on U.S. Department of Energy estimate that one gallon of gasoline puts 19.56 pounds of carbon dioxide into the atmosphere (Energy Information Administration. 2001).

[3] Prices range from $5.50 to $27.40 per ton of carbon dioxide emitted (Kollmuss & Bowell 2007: 34).

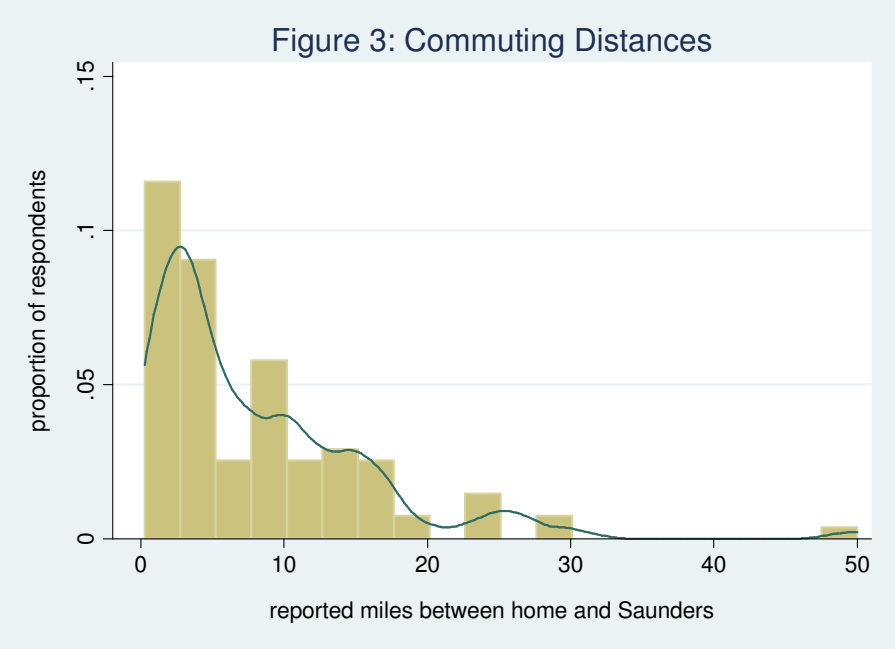
[4] Source: http://www.fhwa.dot.gov/planning/census/2005tp/placeofwork/honolulu_cdp_hawaii.htm accessed 5/20/2007. Percentages were adjusted from the latest FHWA report, to make them comparable to the Saunders categories.

2. Reduce the number of days people come to campus (encourage telecommuting, or adjust class scheduling). Figure 2 illustrates the workweek pattern for surveyed building occupants. The median number of days in the office is five for all categories except graduate students (their median occupancy is four days), though significant variation in number of days in the office exists only for faculty and graduate students.

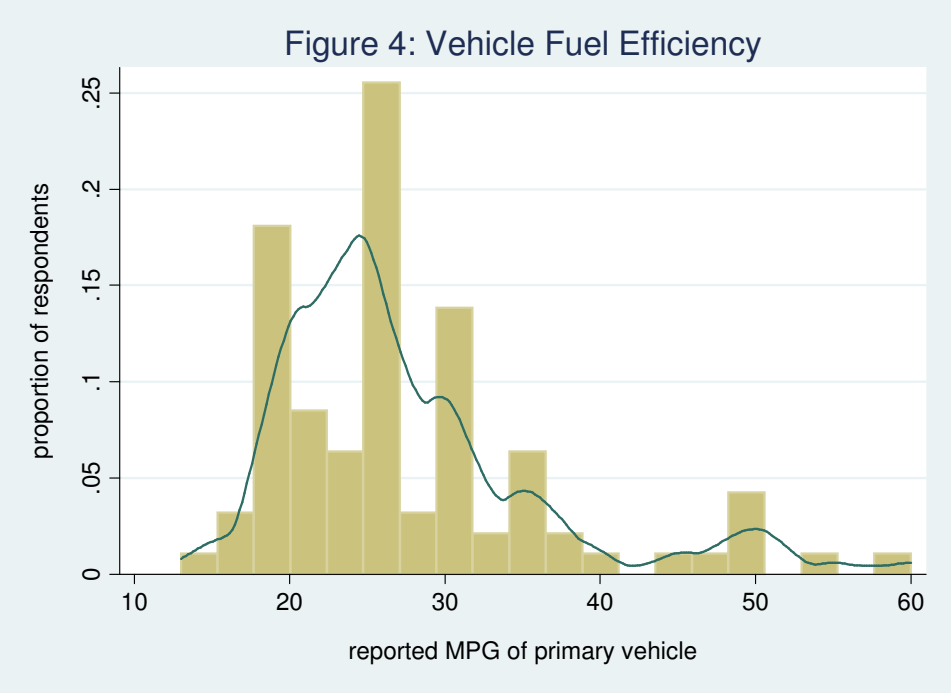


Note: for a box plot, such as figure 2, the interquartile range (25th through 75th percentiles) is indicated by the "box", the median is indicated by a horizontal line within the box, statistical outliers are indicated by *, and the smallest and largest non-outlier values are indicated by the "sticks" or "whiskers". In these data, there is little or no variation among permanent or undergraduate staff. For all categories other than graduate students, the median is five days per week (for gradaute students, the median is four).

3. Reduce the number of miles between home and work (housing incentives). Figure 3 illustrates the distance to work for Saunders survey respondents.



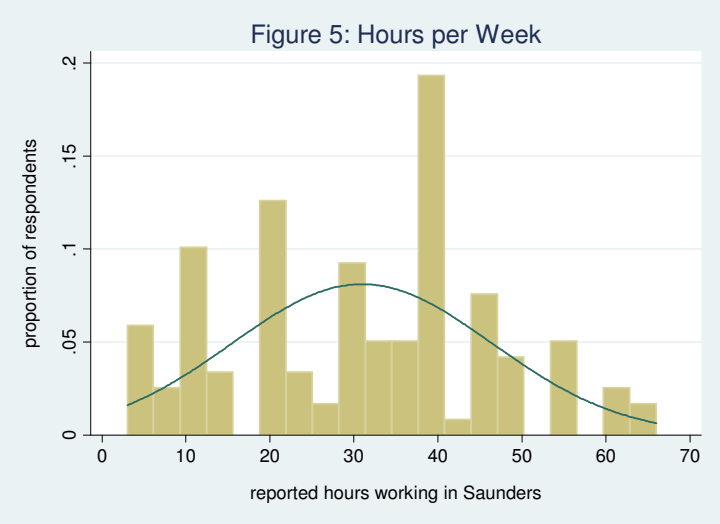
4. Increase the mileage of vehicles (vehicle incentives). Figure 4 illustrates the vehicle mileage reported by those people driving their own motorized vehicle to work. All the very high mileage vehicles (40+ MPG) are motorcycles.



5. Increase the number of passengers per vehicle (carpool incentives). An element in Figure 1, above, illustrates that of the people arriving by automobile to Saunders, 24 % currently carpool.

Workplace Satisfaction

Support staff are of course present in their offices 8 hours per day, 247 days per year. But faculty and research staff sometimes shift substantial amounts of their workweek outside of Saunders Hall. As Figure 2 in the previous section illustrates, faculty work anywhere from 2 to 7 days per week in Saunders. Figure 5 below illustrates that people who work in Saunders are in the building 31 hours per week, on average.



To the extent that faculty and staff describe their workplace satisfaction, they tend to be most satisfied with the lighting and least satisfied with the air conditioning. Table 2 reports the survey results.

Table 2: Saunders Workplace Satisfaction

"The following phrase describes my satisfaction about these aspects of my work space:"

workplace aspect	percent responding "mostly" or "very" dissatisfied	percent responding "mostly" or "very" satisfied
lighting	13.9	86.1
windows	22.0	78.0
temperature	35.0	65.0
ventilation	36.9	63.1
indoor air quality	34.4	65.6

Workplace characteristics, such as lighting and air conditioning account for as much as 31% of variation in work satisfaction (Oldham & Fried 1987). A wealth of literature documents the profound financial costs experienced by any business whose employees must work in suboptimal lighting or uncomfortable air conditioning. Documented conseequences included elevated sick days and reduced efficiency and accuracy for precisely the kinds of office activities that constitute most of the work in Saunders (reading with speed and comprehension, transcribing, composing text, simple algebraic calculations, etc).

It turns out that lighting preferences vary dramatically between individuals, so that a relatively high level of dissatisfaction with the lighting is very common in workplaces where occupants have no control over the brightness of the lighting fixtures, as is the case throughout Saunders. The Lighting Controls Association has published research demonstrating the productivity gains of individually-controlled illumination levels, and they have many resources on their web that speak to costs and feasibility of more personalized illumination in Saunders (DiLouie 2004).

The most common volunteered complaint about lighting in Saunders is that the new fluorescent light fixtures are too bright. Lighting fixtures were replaced throughout the building in 2006, in part based on a previous energy audit of Saunders Hall that found the original illumination inadequate and energy inefficient (Murayama 2001). It may be possible for residents to manually reduce the illumination of their fixtures by de-lamping (removing bulbs from the fixture). Delamping is a very common energy conservation and office improvement technique in the private sector. HECO even provides rebates for delamping, so UH could initiate a program and recover its costs. More information specifically targeted at energy efficiency of the lighting in Saunders appears in the "Going Home" section, later in this report.

Within these survey data, it can be shown that people describing themselves as "dissatisfied" or only "mostly satisfied" with their windows are also significantly more likely to be "dissatisfied" or only "mostly satisfied" with their lighting (chi-squared=29.2, p=.000, gamma=.79). This linkage suggests that technology approaches to increasing natural lighting are a promising approach to improving workplace satisfaction in Saunders. Satisfaction with the windows is dramatically and significantly lower among first floor residents than residents in the rest of the building (chi-squared=19.4, p=.000, Fisher's exact p=.000, gamma=-.65).

Complaints about the temperature are perhaps the most common workplace dissatisfaction in Saunders. Seppanen et al (2006) provide a meta analysis of studies documenting a strong reduction in workplace performance, based on temperature dissatisfaction. About half the Saunders occupants have individual air conditioners in their office, with individual controls. Personal control over the air environment has been shown to significantly improve office worker performance (Wyon 1996; Lomonaco & Miller 1997). Saunders occupants with control over the air conditioning are significantly more satisfied with the temperature (chi-squared=6.6, p=.01, gamma=.47), and occupants without control over their AC are significantly more likely to rate themselves as "very dissatisfied" with their indoor air quality (chi-squared=8.1, p=.000, gamma=.70).

Generating Garbage

While at work, Saunders occupants generate waste products - primarily waste paper, but also recyclable bottles and various other garbage. Paper has been successfully recycled in Saunders for many years. Five large green bins on the ground floor collect recycled paper for the entire building. Individual faculty and program staff collect their waste paper and take it down to the green bins without custodial assistance. UH Facilities hauls off the recycled paper. Other research we've conducted in cooperation with the Sustainable Saunders Recycling Team estimates that about 470 lbs of office paper and newspaper are recycled, while the remaining 97.5 lbs of recyclable office and newspaper ends up in the dumpster. That's a superb paper recycling rate (82.8%, by weight), given the fact that paper recycling bins are not available on each floor. Paper recycling rates higher than in Saunders have only been achieved by aggressively shifting custodial duties for regular trash to individual office occupants (MPWGSC 2001).

One of the Sustainable Saunders projects involved installation of a deposit-bottle recycling program throughout the building, to try to match the impressive paper recycling program. The project was conducted in conjunction with a class assignment in an undergraduate Economics class. The Sustainable Saunders survey indicates that Saunders Hall occupants are aware of and supportive of the bottle recycling program, as illustrated in Table 3.

Table 3: Bottle Recycle Program Impressions

Are you happy about the new beverage container recycling program in Saunders?

Yes	76.9%
No	12.0%
What recycling program?	11.1%

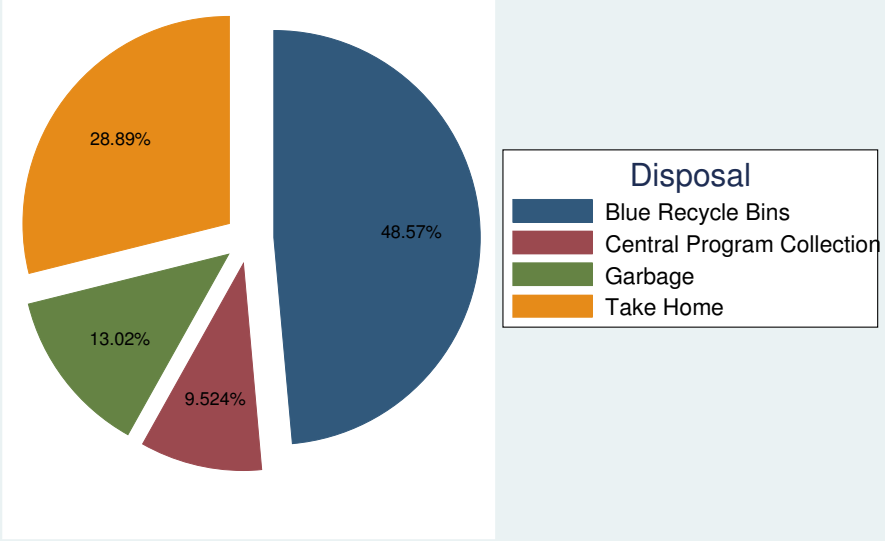
The bottle recycling program achieved very clear success on at least one front - it reduced the number of deposit bottles being dumped into the regular trash by over 70%, according to the data laboriously collected by students from the Saunders dumpsters. But this reduction is small in volume (only 16 fewer bottles going into the dumpster each week) and might not compensate for the program costs (bins, custodial work), according to the student research.[5]

One reason for the small *volume* of recycling improvement of the Saunders experiment is that

[5] A recent study of paper recycling directly addresses the tradeoff in Hawaii between local burning of recyclables in H-Power and true recycling of materials (typically off-island), and finds that the global benefits of recycling paper here in Hawaii, even if it involves shipping the paper off-island, greatly exceed the benefits of burning paper here at H-Power to generate electricity (Beck 2007). Because energy recovery from burning plastic bottles is more limited, the same conclusions about the benefits of recycling hold true for deposit bottles here in Hawaii. Unfortunately, the undergraduate student assessment of the Saunders bottle recycle program was much more limited in scope (assessing only programmatic costs and benefits), and is therefore insufficient to arrive at a global assessment of the costs and benefits of UH bottle recycling.

building occupants were already recycling bottles, and they continue to do so. According to the Saunders survey, 63% of the building occupants generate deposit bottle waste while at work, generating an estimated 474 bottles per week.[6] As Figure 6 illustrates, 29% of the Saunders bottle waste stream gets taken home (presumably for personal redemption). In addition, several departments and programs in Saunders have been collecting bottles in their own offices, with funds for the bottle deposits typically donated to student organizations. An additional 9.5% of the total bottle waste stream is recycled in this fashion, according to the survey.

Figure 6: HI-5 Beverage Containers



All told, then, 87% of the total bottle waste stream is being recycled, in one fashion or other, according to the survey results. This figure incorporates the large segment of the waste stream being taken home - something previously suspected but not directly measured until this survey. 87% is far larger than the estimated 71% recovery rate island-wide (DOH 2006).

Reported bottle disposal behavior, even in an anonymous survey, is a potentially inaccurate measure of actual behavior, due to the social desirability of recycling. But one would expect overestimates of recycling and underestimates of garbage disposal. On the contrary, these survey results actually underestimate recycling and overestimate regular garbage disposal of recyclables[7], based on a comparison to the actual bottle counts conducted by the Sustainable

[6] Average number of bottles consumed per week (2.709) times 175 building occupants. These figures ignore the contribution to the waste stream by people only intermittently in Saunders, which may be substantial.

[7] One plausible explanation is that survey respondents tended to overestimate their bottle consumption, overall, and that temporary building occupants (students coming to class, coming to office hours) inflate the returns in the blue recycling bins.

Saunders Recycling Team, as illustrated in Table 4.

Table 4: Comparison of Survey Estimates and Actual Bottle Counts

	survey estimate	Recycle Team count (average)
bottles dumped in regular Saunders trash per week	62	7.75*
bottles deposited in blue Saunders recycle bins each week	231	291.6

* this figure was 24.0 prior to installation of the blue bins on each floor of Saunders in February 2007

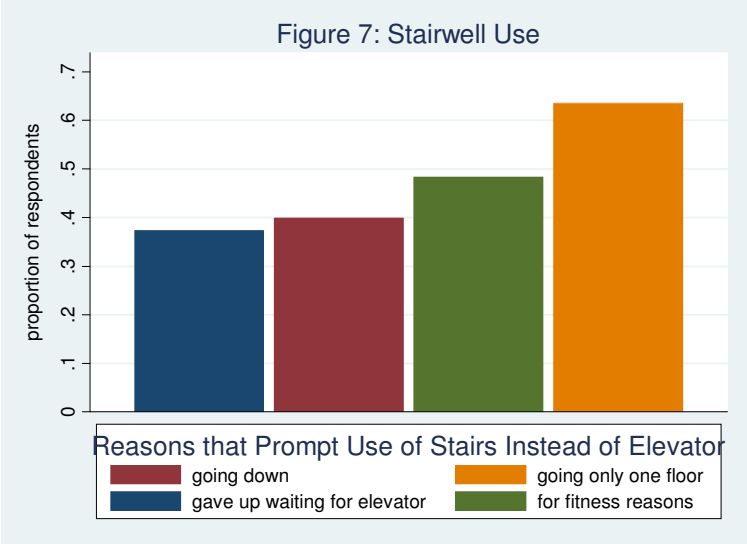
The survey was administered four months after introduction of the recycling bins and well after the weekly volume of deposits in the bin had stabilized, so these take-home and in-program recycling figures probably indicate the pattern that is likely to continue in the absence of any major changes.

Getting From Floor to Floor

When arriving and while at work, building occupants need to move among the seven stories of Saunders Hall. A surprisingly large number of survey respondents reported taking the stairs, instead of the elevator (about 40 percent of the time, on average, though only 2 to 5 percent of occupants rely on stairs exclusively). Use of the stairs tends to decline for occupants on higher floors, so that occupants on the second floor of Saunders use the stairs about 50% of the time, while occupants on the sixth and seventh floors use the stairs about 30% of the time.

Impediments to taking the stairs include a number of factors, but time is the most oft-cited consideration (33% of respondents cited this factor). In separate research, we determined that elevators are, not surprisingly, faster than stairs in almost all circumstances. But the time savings are quite modest, by our estimates - saving perhaps 35 seconds by taking the elevator instead of the stairs when traveling from the first to the seventh floor. About one in five Saunders occupants volunteered essentially no reason for taking the stairs - they acknowledge their choice as rooted mostly in habit.

As Figure 7 indicates, the single most important circumstance driving stairwell use is the need to travel only one floor. 64% of respondents cite that circumstance as one that prompts them to take the stairs. Several other factors, including wait times and fitness, are cited frequently by respondents as driving them to choose stairs over elevators.



Leaving Work

Other data about electricity use for Saunders Hall demonstrates that overnight electricity usage falls dramatically, as occupants turn off lights and computers for the evening. According to self-reports in the survey, virtually every person (97.5%) turns off their lights when they leave for the day. Any evening or weekend walk-through of the building will confirm these reports. This behavior pattern likely emerged suddenly and only recently, when the lighting fixtures were replaced throughout the building last year. Until 2006, each office and classroom in Saunders was lit with mercury vapor lights that took about 20 minutes to warm up, according to an energy audit of Saunders Hall (Murayama 2001). As a result, it was common practice for building occupants to leave the lights on 24 hours a day, 7 days a week. Other research by PPC shows that this practice was inflating the electricity usage of the building by approximately 500,000 kWh per year.

By contrast, a substantial number of building occupants (8.5%) leave their computers on all night and/or all weekend, for a variety of reasons, and virtually every person leaves their computer peripherals on all night and weekend. Volunteered explanations for leaving the computer on all night fell into one of the following categories (percent of volunteered responses in parentheses):

- To allow remote access to the computer from home (4.3%)
- To allow overnight estimation for research (8.6%)
- To conduct hard drive scans and virus scans (7.1%)
- To perform scheduled file backups (5.7%)
- To perform scheduled software updates (5.7%)
- To save time in the morning (8.6%)
- Absent-mindedness or convenience (10%)

•To reduce wear and tear on the computer (7.1%)

The electricity used to power 8.5% of all Saunders computers in all hours the building occupants are away from the office is substantial, and the electricity used to power virtually every peripheral in Saunders during off-hours is even more substantial. Table 5 presents the surveyed proportions of overnight computer, and the estimated total electrical loads, based on some measurements of representative computer equipment.

Table 5: Electricity Drains for Computers and Peripherals Left On

	percent of respondents who leave the equipment in standby mode	estimated power drain for each peripheral in standby mode*	estimated cumulative weekly power drain in Saunders**
CPU	8.5	200 watts	64.5 kWh
monitor	88.9	1 watt	22.7 kWh
printer	90.5	3 watts	68.9 kWh
power strip	92.1	5 watts	212 kWh
total			368 kWh

* Based on measurements of representative equipment in the Public Policy Center.
** Estimates include adjustments for the number of hours away from the office for those who reported leaving the equipment on when they left for the day.

Together, these results suggest two main avenues for reducing the electricity demand of computers left on overnight.

1. Education: Most IT professionals advise that leaving a computer on does not increase the life expectancy of modern computers. Another approach might involve a focused campaign to get Saunders occupants to enable the Energy Star “hibernation” feature that automatically shuts their computers down after a specified period of inactivity. For those who must perform analyses, scans, backups and updates in off-hours, hibernation can save substantial hours of computer idle time. According to survey responses, 7% of respondents have already implemented this feature. Even among the majority of Saunders occupants who power down their computers, very few eliminate the “standby” power drain that occurs for computers and peripherals by physically turning off the power button for their monitors and printers. As Table 5 indicates, peripheral equipment remains on standby mode overnight and weekends for the vast majority of Saunders respondents, and there is a small power drain for doing so. Power strips drain about 5 watts of

electricity, even with nothing plugged in.

2. Reminders and incentives: The most common volunteered explanation for leaving computers on has nothing to do with productivity or specific intent - it's just easier to do so, there are no real incentives to avoid it, and awareness of the consequences of doing so is limited. Even faculty requiring remote access or off-hours operation of their computers could reduce their energy impact by turning off monitors and printers. If every Saunders occupant physically turned off their printers and monitors, it would reduce the energy load for the building 92 kWh per week.

To put these electrical loads in perspective, Saunders uses about 2.5 million kWh a year, based on other research being conducted by the Public Policy Center. That's costing UH about $400,000 per year. The potential electrical savings from better computer power management are on the order of only 2 or 3 thousand dollars per year. But the education and reminder efforts are essentially free. In addition, it's worth pointing out that the 368 kWh of unnecessary electrical consumption is pumping an estimated 721 pounds of carbon dioxide[8] into the atmosphere each week

Conclusions

The Saunders survey provides glimpses of a number of seemingly trivial behaviors at work that accumulate into real environmental consequences across a large number of office employees. The survey presents opportunities for carefully estimating these consequences in a typical office workspace, and this initial report describes the challenges and possibilities within the context of Saunders Hall. Lighting and air conditioning adjustments present a happy opportunity to reduce energy use and improve occupant satisfaction and productivity. Other environmental impacts of the workplace (transportation, computer use, waste generation) might benefit from changes in public policy to more directly link individual actions to the costs they cumulatively impose on the globe. Deeper elements of the survey that are not addressed in this report present opportunities for contributing to the psychological, economic, and policy literatures about environmentally consequential workplace behavior.

[8] Based on U.S. Department of Energy estimate that generation of one kWh through petroleum combustion (the primary source for Oahu electricity) puts 1.96 pounds of carbon dioxide into the atmosphere (Energy Information Administration. 2000).

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