Shut the Sash

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Introduction

Fume hoods are the light switches of HVAC systems (Heating, Ventilation, Air Conditioning). Technically speaking, a fume hood is a ventilated glass enclosure that contains fumes and vapors of hazardous chemicals by removing air from the enclosure, and, by association, the lab room (see Figure 1). Fume hoods have a sash at the front that dictates how much air is sucked out of the room – the higher the sash, the more air is exhausted. Fume hoods are like light switches because they are often left open when not in use.

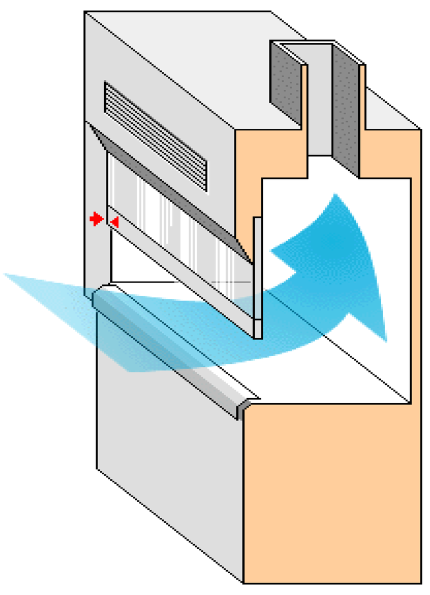


Figure 1: Diagram showing basic fume hood flow. Front sash height dictates amount of air sucked from room.

Image source: http://www.ehs.ufl.edu/programs/lab/fumehood/

This is a problem when it comes to energy because every cubic foot of air that enters a lab room has been cooled and dehumidified from the raw outdoor air. In laboratory buildings especially, more energy is consumed by the HVAC system than any other process. Thus, any air that is unnecessarily removed from the lab room by a fume hood represents energy and money that is going down the drain. In fact, fume hoods that are left open constantly will consume as much as three residential homes[1]. This is where the UCSD Shut the Sash (StS) Program comes in. As part of a campus-wide building automation system, the sash height of 86% of campus fume hoods are continuously logged. This allows the StS program to determine which hoods are being left open and wasting energy.

UCSD is not alone in its effort to reduce the average sash height – universities across the nation have developed their own unique campaigns to attack sash height. A brilliant team at MIT developed a DIY sash height alarm (called MASH: Motion And Sash Height) that simply beeps to notify lab members when a sash has been left open while not in use[2]. With the goal of developing a robust sash campaign, the StS program decided to test out this device and determine if it could have a positive impact on fume hoods of UCSD.

Project Goals

The ultimate goal of the Shut the Sash Program is to develop a standard culture across all laboratories that encourages the habit of closing the sash when it's not in use. To achieve this, it is important to visually show labs how their behavior correlates to energy through regular monthly sash reports. Unfortunately, habits are notoriously hard to alter, so a device such as the MASH sash alarm will step in where the reports fail to motivate a change in behavior. With these goals in mind, the StS Program was interested in completing the following tasks:

- Develop an automated software that analyzes raw hood data to determine worst performing hoods, create time plots of hood use, and calculate average hood statistics based on building.
- Design a monthly reporting template that is concise and motivates action
- Construct several MASH devices and perform a trial test to see if this device will be useful at UCSD

Materials and Methods

The energy used by a fume hood depends entirely on the air that it rejects, and the amount of energy that was used to bring that air to the desired lab room temperature and humidity level. For example, a typical San Diegan day is 70 ºF with 70% relative humidity. This air must be cooled past the condensation temperature and then adjusted to the temperature desired by the lab occupants. Thus, the energy waste per fume hood is calculated from its flow in cfm (cubic foot per minute). Because the exact conditions of outdoor air vary, the cost per cfm varies as well. However, the Lawrence Berkeley Lab Fume Hood Calculator was used to estimate the average cost per cfm in San Diego as $4.31[1].

The resource that made this program possible was access to sash height data across campus through the Utility Department's building automation system. While it is possible to estimate sash height based on air flow in and out of labs, the calculation of wasted energy is much less precise. Subsequently, a Python coding environment was used to digest raw data from the building automation system. The algorithm calculates a usage value for each hood based on the number of 30 minute intervals that it was left at the same height (the fact that the height does not change for so long implies that it is not being used). Since the exact line between "good performance" and "bad performance" is blurry, the algorithm picks out the hoods with usage values that are greater than one standard deviation above the average value.

The labs chosen to test out the MASH device were among those with a UCSD Green Labs Certification[3] since campus Sustainability already had a relationship with one or more of these lab members. Unfortunately for the experiment, this meant that the labs were already sustainably conscious, and already had decent fume hood habits. Despite this, however, a distinct downward jump in average sash height is visible post-installation (see Figure 3).

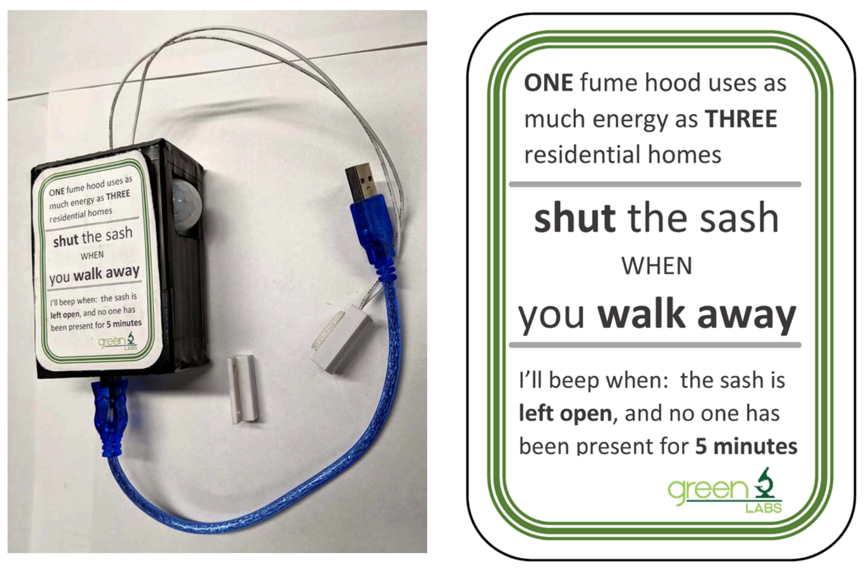
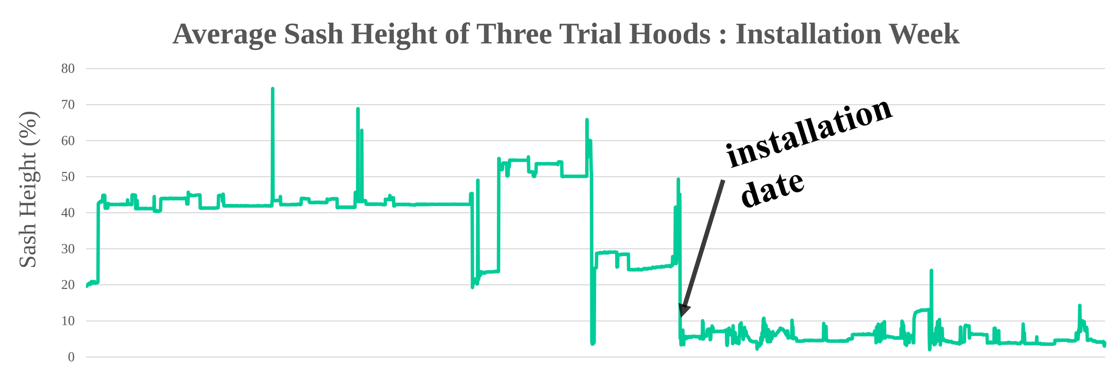


Figure 2: (left) constructed MASH device per MIT Green Labs instructions[2] and (right) UCSD info label.

Results and Outcomes

The MASH devices were constructed (Figure 2) and installed in three trial labs. Figure 3 shows a timeplot of averaged sash height across these three labs before and after the installation date, as well as tabulated results.



	Trial Hood #1	Trial Hood #2	Trial Hood #3
Avg % open	109 % → 8.2 %	0.87 % → 0.44 %	12.5 % → 8.5 %
Avg cfm	338 → 184	(no flow data available)	126 → 102
Est annual savings	$1360 → $741 = **$619**	–	$506 → $411 = **$95**

Figure 3: (top) timeplot of sash heights averaged across all three trial labs, (bottom) tabulated estimated savings per year

While the results of the MASH trials reveal a compelling 86% drop in average sash height, a lack of funding prevents the installation of MASH devices across campus. Instead, the StS Program will follow the following process:

1. Select worst performing hoods across campus
2. Work with these labs through monthly reporting to motivate reduced sash height
3. Install MASH if three months of reporting is futile
4. Repeat

Conclusions

While the unfortunate COVID shutdowns prevented the StS Program from being implemented, it gave the StS team time to develop a coherent monthly report that will motivate changed habits. The report (Figure 4) has gone through a month and a half of iterations and has improved from feedback from several groups across campus. Where the report fails to alter lab habits in the future, the MASH device certainly will, as shown from the previously conducted trial experiments.

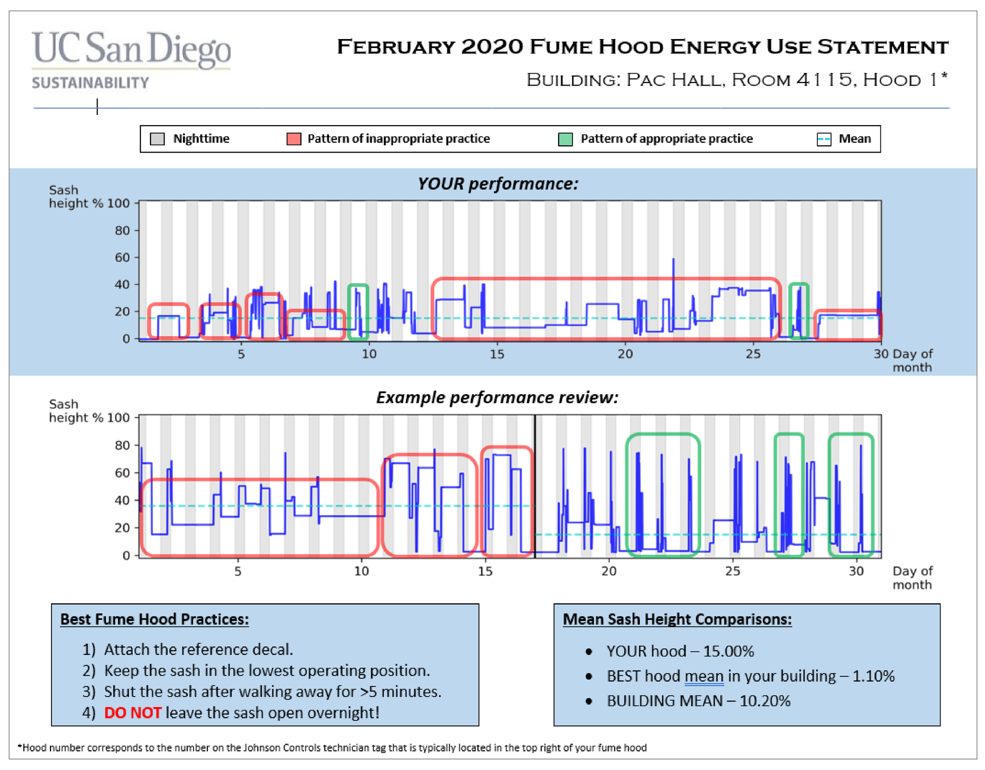


Figure 4: example of monthly report template.

Future Goals

Since the COVID shutdowns will outlive the current StS team, we hope that a future team will be able to implement this developed program at a later date and continue to improve it through thoughtful trial and error until UCSD labs are able to sustain good hood habits on their own.

Ultimately, we hope that this StS Program will motivate other universities and relevant organizations to develop their own programs aimed at lowering the average sash height. Preventing fume hood energy waste is a low-hanging fruit when it comes to the global issue of climate change – all it takes is the formation of new habits to have a real impact.

Literature Cited

1. Mills, Even, et. al., *Laboratory Fume Hood Energy Model*, Berkeley Lab, http://fumehoodcalculator.lbl.gov/index.php
2. Munden, Ethan, el. al., *M.A.S.H.*, MIT Green Labs, https://greenlab.mit.edu/mash
3. *UCSD Green Labs Program*, UCSD Sustainability, https://sustain.ucsd.edu/involve/green-labs.html

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