

SUSTAINABLE SAUNDERS AC SHUTDOWN PROJECT



a cooperative plan between the following partners:

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Because Saunders Hall is a non-laboratory office building in which the residents regularly complain about offices that are too cold, it is an excellent candidate to consider shutting down the air conditioning system. Such an approach presents a win-win situation - a lower electricity bill and potentially more comfortable and productive employees.

In broad terms, the air conditioning system in Saunders has three components:

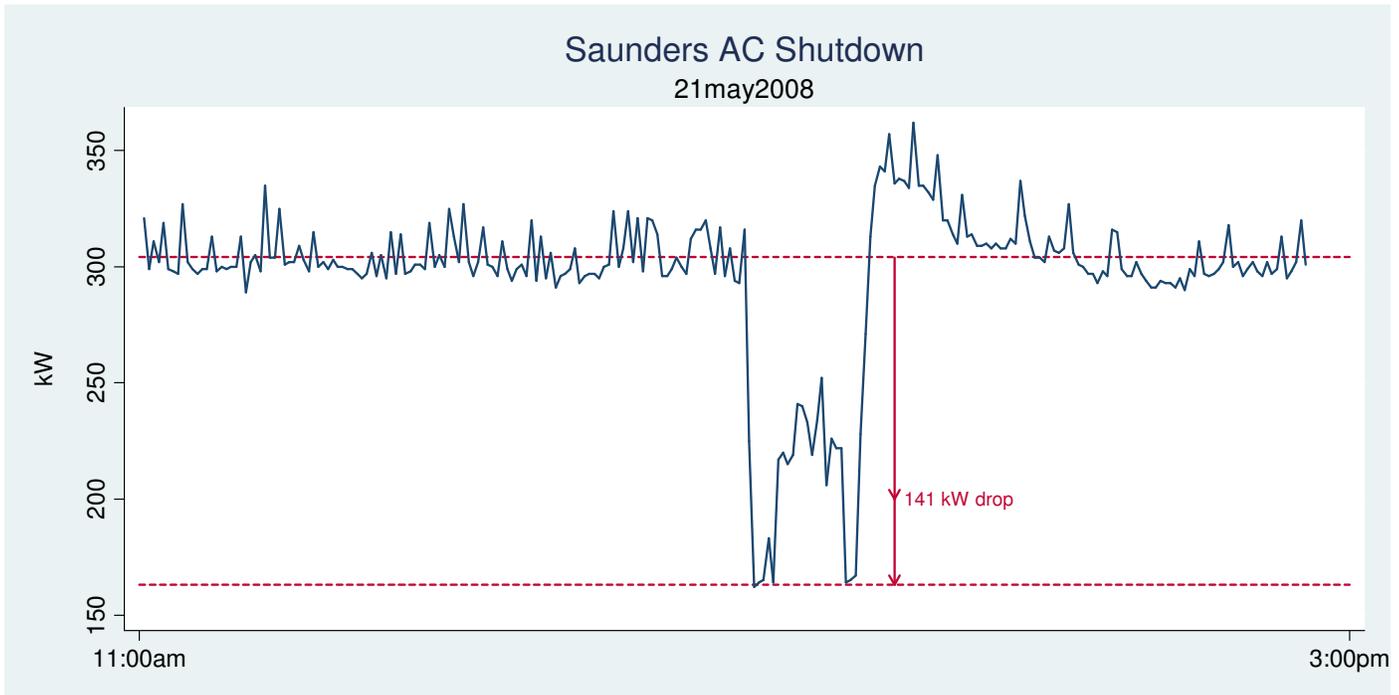
- (1) a **Chiller** cools water and then circulates it in pipes throughout the building
[currently runs 24 hours a day, 365 days a year]
- (2) fourteen large **Air Handling Units** (approximately 2 per floor) blow air across chilled water pipes and into offices through ductwork
[currently run 24 hours a day, 365 days a year]
- (3) 118 small **Fan Coils** serve the same function as the air handling units, blowing air across the chilled water pipes and into offices. But each fan coil serves a single office and can be turned on or off by the office occupant. Approximately 45% of the square footage of Saunders is cooled in this manner.

summary:

approximately 45% of building occupants are already saving electricity and making their offices more comfortable, by turning off their own fan coils. The central AC system could be turned off on nights and weekends, like other buildings on the quad and virtually all private sector office buildings. Thanks to very detailed energy load data we have been collecting since April 2007, we are able to estimate that shutting down the AC Chiller and Air Handling Units at nights and on weekends would reduce the annual electricity bill by about 30% in Saunders. That's over \$100,000.⁰⁰ in savings, at current electricity prices. The central AC chiller is already shutting down many evenings on a cyclical, but very limited basis. Thanks to equipment identification and upgrades provided by HECO, the AC shutdown would come at virtually zero expense. AC shutdown would introduce heat difficulties for three computer server rooms that have been located in Saunders and have no dedicated cooling systems.

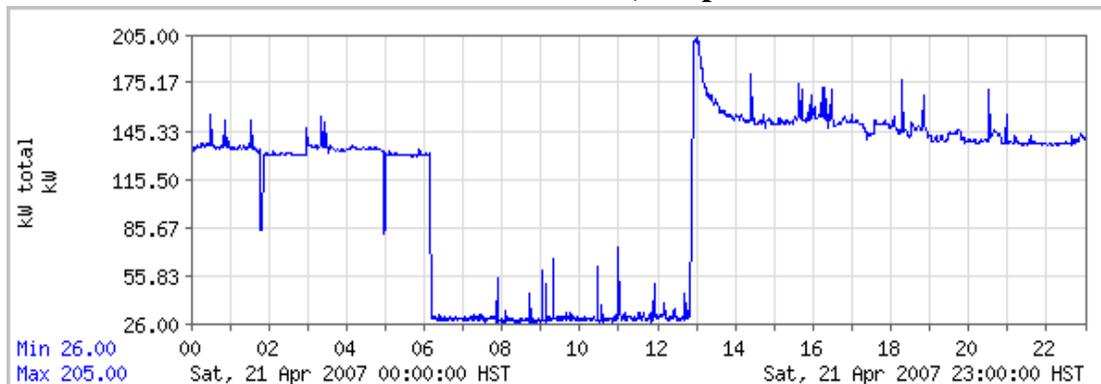
AC shutdowns generate substantial energy savings

We know from a recent test that a chiller and AHU shutdown reduces total electrical usage substantially. On May 21, the chiller and all air handling units were cycled off and on twice between 1:00 and 1:30pm. This test clarifies that such a shutdown immediately reduces the total electrical load for the building by 141 kW.



Depending on time of day, there may be a power surge required to “catch up” with the foregone cooling, but we know from a previous and more lengthy Chiller shutdown in April 2007 that the surge is only on the order of about 50kW above normal initially, and the surge declines to zero in about an hour.

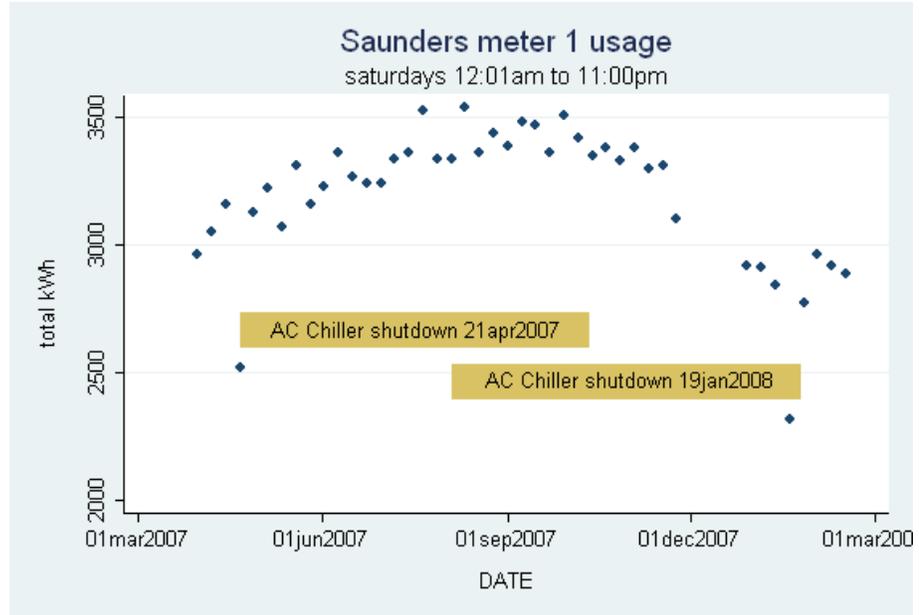
AC Chiller Shutdown, 21apr2007



In fact, two AC Chiller shutdowns have been conducted on Saturday mornings in the past year for maintenance purposes, and they each saved approximately 550 kWh over a 6 or 7 hour period.

Power Use, 12:01 am to 11:00pm, Saturdays

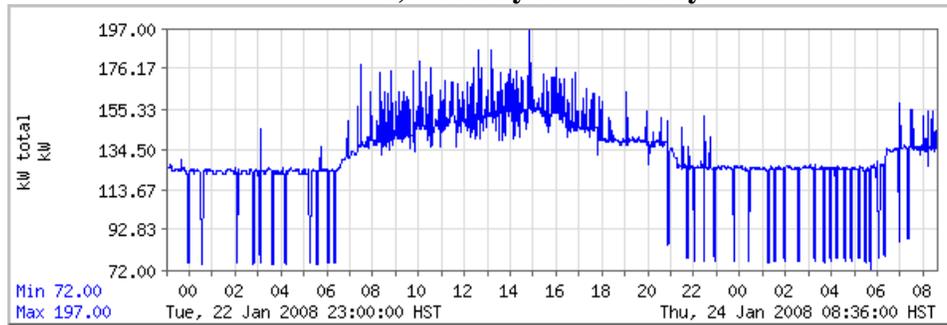
date	total kWh
10nov2007	3300
17nov2007	3310
24nov2007	3100
29dec2007	2920
5jan2008	2910
12jan2008	2840
19jan2008	2320
26jan2008	2770
2feb2008	2960
9feb2008	2920
16feb2008	2890
31mar2007	2960
07apr2007	3050
14apr2007	3160
21apr2007	2520
28apr2007	3130
05may2007	3220
12may2007	3070
19may2007	3310
26may2007	3160



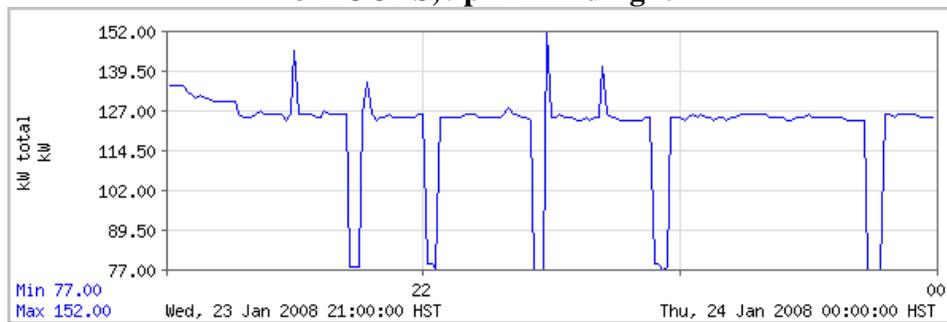
Saunders Chiller already shuts down intermittently

Substantial components of the Saunders AC system are already shutting down intermittently. The AC Chillers (or perhaps cooling towers) ‘downcycle’ for about 5 minutes repeatedly throughout the winter nights. Each cycle reduces the building’s energy load by about 50 kW, but only for about 5-10 minutes of each hour.

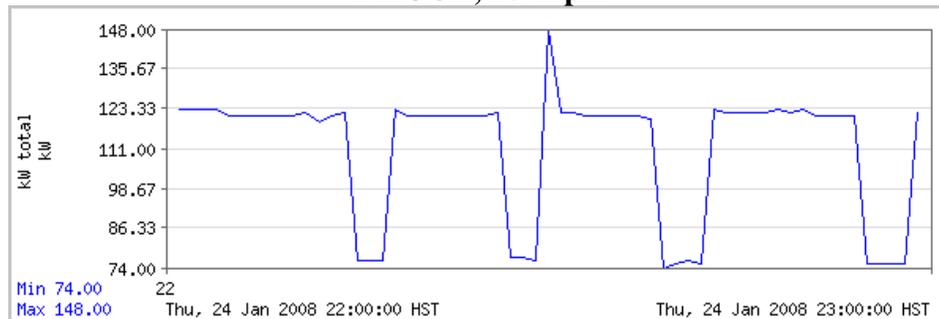
1.5 DAYS, Tuesday to Thursday



3 HOURS, 9pm-12midnight

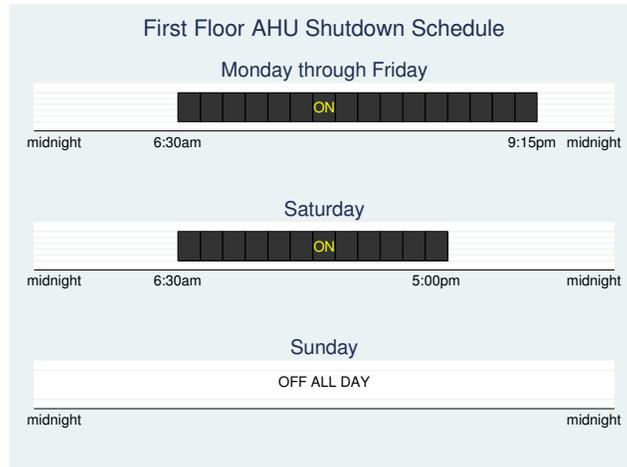


1 HOUR, 10-11pm

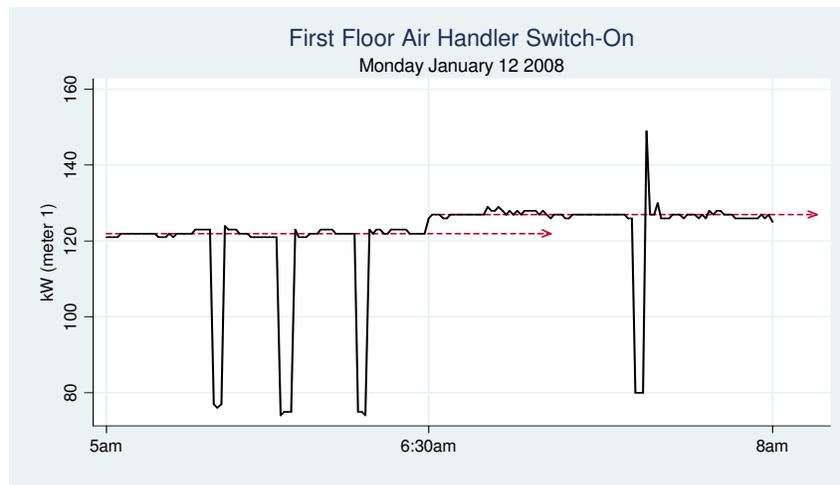


First Floor Air Handlers demonstration shutdown working well

Beginning December 19, 2007, an experiment was launched to shut down the air handling unit for the first floor of Saunders Hall. Previous research by Sustainable Saunders demonstrated that first-floor occupants of Saunders are significantly less satisfied with the temperature in their offices than the rest of the building occupants. In a word, it's too cold. Overall, it seems wasteful to air-condition the building overnight. So a schedule for overnight and weekend shutdown of the first floor AHU was established, as follows:



All told, this schedule shuts down the AHU for 4,264 hours per year. The rated specs for the first floor air handling unit tell us that the motor draws 7.3 amps at 460 volts. That's 3.358 kW at any one moment. Thanks to the very detailed power data provided by the Saunders building meter, the energy savings of even this single AHU shutdown is clearly evident, even when conflated with the 'downcycling' of the chiller. The following figure illustrates the 3 kW "step" evident, as the building's electrical load increases from a steady 122 kW draw to a steady 125 kW draw each morning. Across a year, the shutdown of this AHU translates to an energy savings of 14,319 kWh annually, or 0.6% of the building's energy use. Doesn't sound like much? Consider this: Saunders has 14 AHUs



Energy savings can be precisely estimated

The electricity meter data we have been collecting since April 2007 allows us to perform some precise calculations about how much energy would have been saved in the past year if the AC had been turned off at any schedule we would like to consider. One of the data streams is dedicated to the AC Chiller and some small constant power loads, while the other data stream is a confab of all the remaining loads in the building, including AHUs, computers, lights, etc.

To calculate the energy savings for a shutdown of the chillers, we took a careful look at two previous shutdowns of the chiller (21april2007 and 12jan2008). In each case, the power reduction of the chiller was unmistakably 109 kW. To calculate the energy saved by turning off the air handlers, we took a careful look at the May21 test shutdown, because it was the only shutdown of the air handlers in the past year. Subtracting out our estimated power reduction for the chiller (109 kW), we estimated that the power draw of the air handlers is 31.8 kW. The total potential savings is approximately 141 kW each minute the AC remains off, except for the fact that the chiller already shuts down for short durations each winter evening..

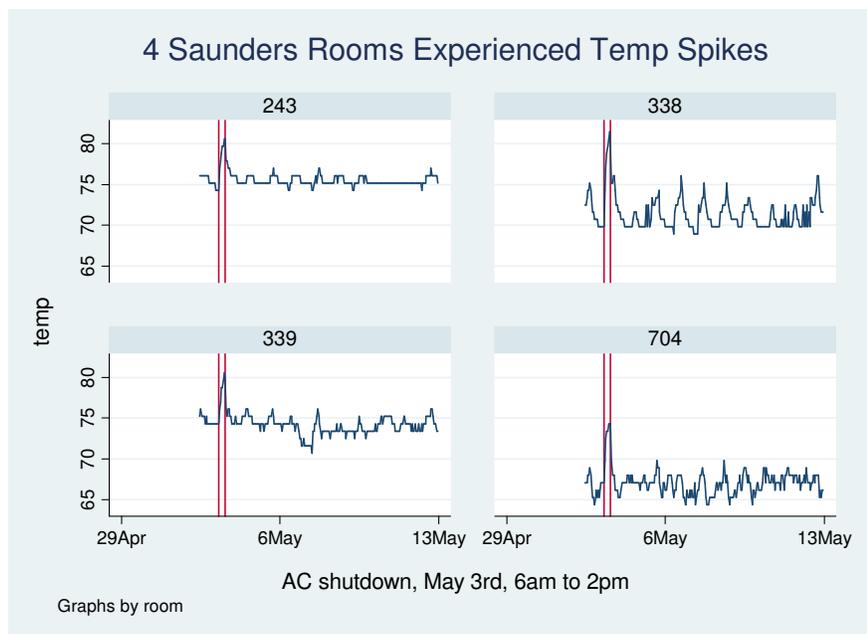
We took the meter data for saunders that has been accumulating every 60 seconds since March 30, 2007. For a for a variety of potential shutdown scenarios, we subtracted 31.8 kW (the estimated AHU shutdown savings) and reset meter1 data to 26kW (to account for chiller shutdown savings in a way that accommodates the chiller downcycling that is already occurring). Our estimates of likely energy savings are as follows:

shutdowns scenario	energy saved	as % of building load	in dollars	in tons of CO2 emissions
11pm to 5am, 7 days a week	305,479	13.3%	\$48,876.77	299.3
11pm to 8am, 7 days a week	456,967	19.9%	\$73,114.72	447.8
11pm to 8am weekdays, plus 5pm Saturday to 8am monday	616,764	26.8%	\$98,682.18	604.4
11pm to 8am weekdays, plus all weekend	684,843	29.8%	\$109,574.90	671.1

Some computer server rooms might experience temperature spikes

On May 3, all Saunders AC chillers and air handling units were shut down on a Saturday morning, from 7am to 2pm. Prior to that shutdown, we placed temperature and humidity sensors in 27 representative locations throughout Saunders Hall. Our equipment logged the temperature and humidity each hour for an additional 10 days. No humidity spikes were recorded, though many locations throughout Saunders experience humidity levels between 58% and 75%, on a routine basis.

We identified four rooms that experienced temperature spikes during the AC shutdown on May 3 - three in computer server rooms (rooms 243, 338 and 339), and one in a large south-facing conference room on the top floor (room 704). The temperature spikes are evident in the following graphs (the AC shutdown period is the interval between the red lines).



The temperature spike in the conference room (704) merely raised the temperature from a frigid 67 degrees to the average temperature maintained by office occupants in saunders who can control their fan coils (75 degrees), so we do not consider this a major concern.

The Saturday morning AC shutdown raised the temperature in the small computer server rooms to about 80 degrees, and this may be cause for concern. We expect the heat gain in these rooms to be largely unrelated to time of day, so nighttime shutdowns would be expected to spike the temperature in these rooms, similarly, to about 80 degrees.

During the May 3 AC shutdown, we observed no temperature spike in room 721a - home to a large computer server bank. But special precautions had been taken that day, and further investigation may be warranted.

Conclusion

Regardless of the small number of computer-related temperature spikes that might result from scheduled AC shutdowns, the economics of shutting down the AC at night and on weekends is incredibly compelling. Even at current electricity prices, nighttime and weekend shutdown of the AC system can be accomplished at zero cost and can generate savings of more than one hundred thousand dollars each year in Saunders - forever.¹ If the temperature spikes are problematic for the computer server operators, relocation is one alternative solution. Another solution is to install a dedicated separate AC system for these rooms - something that the energy savings could pay for many times over.

¹ If UH were selling its carbon offset credits, this project could be generating between \$3,691 and \$18,388 each year for the university, at the most recent published values of those emission reductions (between \$5.50 and \$27.40 per ton of avoided CO2 emissions { Kollmuss & Bowell 2007:34})