KLAMATH HALL: IT'S ELECTRIC!

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ABSTRACT

A trip to the Willamette Atrium at the University of Oregon campus can lead to interesting discoveries. One day, our group visited the atrium to attempt to find out how air moves in the space. What we eventually discovered was something quite odd: at the junction between the Willamette Atrium and the third floor of Klamath Hall, we discovered a draft sweeping through the hallway. This immediately captured our attention; the breeze was unusually strong. So, we wanted to investigate further.

We initially thought that the atrium caused the draft – perhaps the convective current produced lots of air and its only outlet was through the hallway. This proved wrong. What was it? A hint came from one of the chemistry students who worked in the hall. Apparently each lab has its own ventilating system. The hoods in the classrooms quickly suck in air to ensure no harmful chemicals get into the main ventilation system. Aha! Naturally, as architecture students and sponsors of sustainability, we thought we could use the draft and convert its energy into electricity.

1. INTRODUCTION

The demands of scientists present many challenges for the designer. Science buildings require large equipment, sizable working spaces, and specialized ventilation; these have serious design implications. The designer must accommodate these special needs, or, surely negative consequences will follow. Such is the case on the third floor of Klamath Hall; the building was designed with a mechanical system that was not suitable for its function as a chemistry building.

The double-loaded corridor on the third floor of Klamath Hall, aside from being cramped, presents serious issues in comfort. Air whips through the hallway making it extremely unpleasant. Initially we thought that the passively ventilated Paul Olum Atrium, directly connected to the hallway, created so much air movement that the air could only escape through the hallway. We performed several tests, and noted that the wind inside the atrium was negligible: the temperature difference between the top and bottom floor was minimal and the anemometer had low readings. So, what was the source of the draft?

The answer lay in the function of the building. The classrooms lining the third floor hallway of Klamath Hall are chemistry labs. After asking around, we discovered that each room is self-ventilated; they are equipped with powerful ventilating hoods that suck in air and release it directly outside so as to protect the main spaces from any harmful air pollutants. With this new knowledge, we asked some serious questions. How much wasted energy, in the form of wind movement, is produced? Is there any way to stop the air from flowing? Is comfort being compromised in the hallway? What can we do to make the experience better? Does the draft perform any practical functions?

These questions consumed our minds. So, we asked the students and faculty in the hall about the draft. They had noticed it and it bothered them: they wore jackets indoors and it blew their posters off the walls – it was truly inconvenient. As it turned out, the draft was the by-product of altering the ventilation system to suit the special needs of the chemistry lab. Initially, we thought of testing the wind speed to see how it measured up with ASHRAE Standards but decided this was not a fruitful enough endeavor. Surely, comfort is sacrificed in the hallway but nothing could be done about it. So, we put our ECS minds to work: perhaps we could harvest the air's movement to produce electricity. This would surely be a worthy experiment – what if the draft could be used to light up an entire classroom for the day? This would reduce the need for electric lighting, if at least a little bit.

Saving energy or using energy as efficiently as possible is a great topic for study in this day in age since the energy usage of buildings has been found to produce negative effects on the environment. Also, this experiment is extremely useful. Surely there are other buildings where unintended drafts occur and if that energy could be used to do something useful, at least something positive could come from an uncomfortable space.

2. HYPOTHESIS

The air speed through the third floor hallway in Klamath Hall flows fast enough to power a 60-W light bulb.

2.1 Guiding Questions

- How fast is the air flowing through the hallway?
- What contributes to this draft? Is it the pressure difference between the hallway and the lab rooms?
- Is the air speed greater during the day with the doors in the hallway open or at night when the doors are closed?
- Since wind has been created, can we use this energy in a productive manner?
- How much wind speed is required to generate 60 W of power?

3. METHODOLOGY

1. First, we blew plastic bubbles in the hallway to get a general idea of the air's flow. We noted the direction of the flow; this helped to determine how to position the anemometer to test the wind speed.
2. Using an anemometer, we measured the air speed through the hallway on the third floor at different locations (about 6' apart, starting right before the entry) and at different heights (2', 4', 6', 8' above the floor). This showed us where the air speed travels the fastest in the hallway.
3. We performed the test during the week (i.e. Monday-Friday) when classrooms are open and on the weekend when the doors are closed. Since the open classrooms had such an effect on the air speed, it was necessary to test both during the week and on the weekend for a complete set of data.
4. Next, we put our data of the airflow through the hallway on a chart to figure out where we could put a device so it would produce optimal power.
5. Then, we bought an electric, DC motor and a propeller at a hobby store: the ones for toy airplanes. We then extended the wings of the propeller by adding strips of cardboard paper. Each wing was 11" long so the whole device, including motor, was two feet long. We connected the propeller to the motor using a glue gun and our device was ready.
6. We placed the device in four locations where the draft was at least 4 miles per hour (after some online research, we discovered that this would be the minimum amount of wind speed required to generate electricity). Using a voltmeter, we recorded the voltage and milliamps produced by our generator. We performed the experiment both during the week and at night to get a complete set of data.

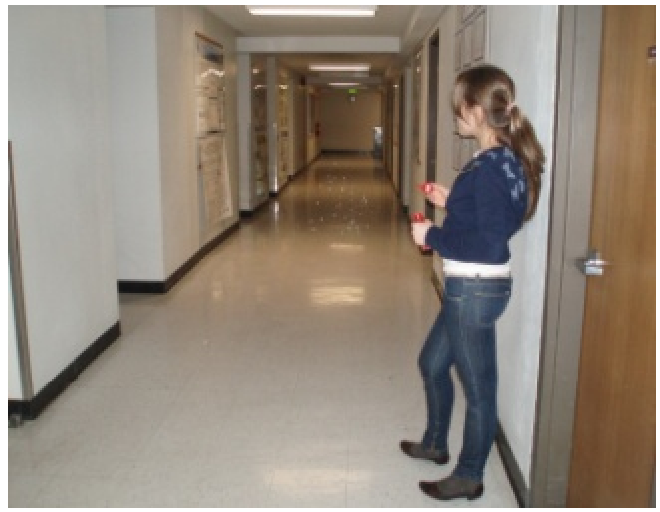

Fig. 1. Testing for wind direction using bubbles.

Fig. 2. Testing for wind speed using an anemometer.

4. DATA

The information presented reflects where we took data from the anemometers, how high the wind speed was in different areas, and then the energy produced in the four areas with the most consistent and high air speed.

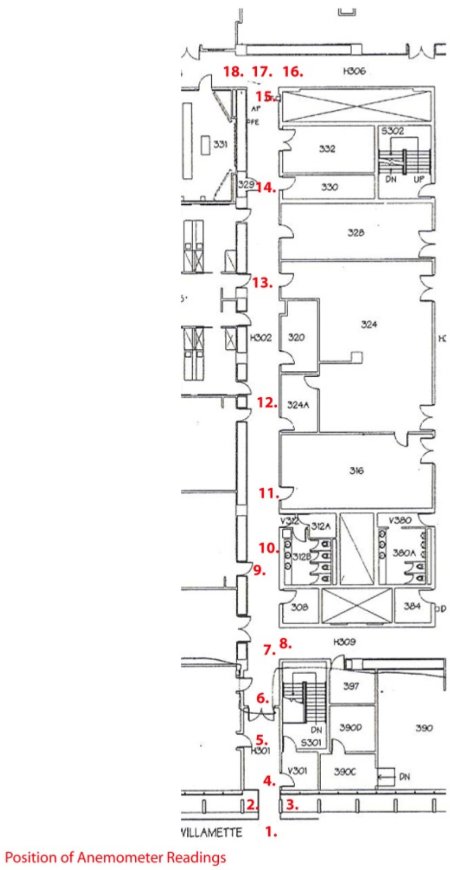

Fig. 3: Plan with locations of anemometer readings.

TABLE 1: AIR SPEED, DOORS OPEN vs. CLOSED

PLAN LOCATION	HT. ABOVE GROUND (ft)	AIR SPEED DOORS OPEN (mph)	AIR SPEED DOORS CLOSED (mph)
6	2	5.12	4.45
	4	5.12	4.02
7	2	5.06	3.33
	4	5.54	3.5
10	2	4.60	4.03
	4	4.17	3.76
12	8	4.39	??

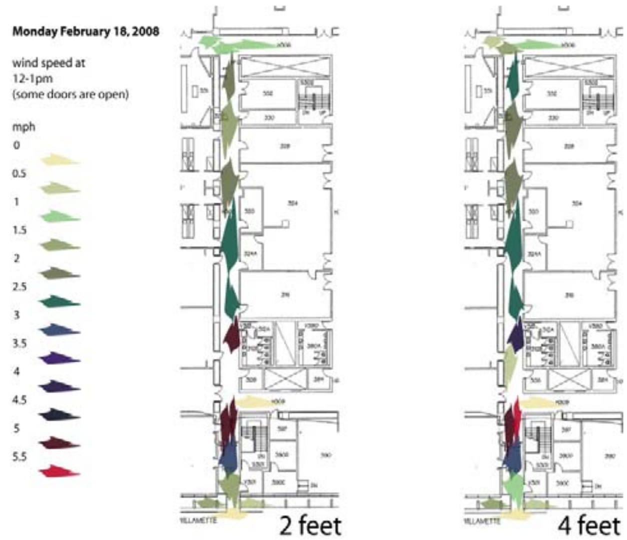

Fig. 4: Diagram of anemometer readings (doors open, Monday, February 18, 2008).

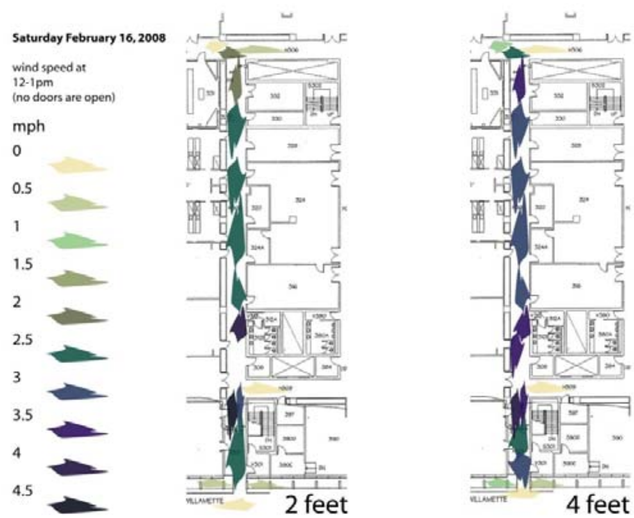

Fig. 5: Diagram of anemometer readings (doors closed, Saturday, February 16, 2008).

The air speed in the hallway was fastest in locations 6, 7, 10 with the maximum air speed being 5.54 miles per hour. These locations became the places where we tested our device.

TABLE 2: ENERGY PRODUCED BY DEVICE WITH DOORS OPEN

MAP LOC	HT ABOVE GRD	WIND SPD (MPH)	AVE VOLTAGE (V)	AVE CURRENT (A)	POWER (W)	POWER (Kw)	AVE HOURS PER DAY	ENERGY PRODUCTIO N PER YEAR (kWh)
6	2 ft.	5.12	0.013	0.005	6.5 X 10^-5	6.5 X 10^-8	10	2.4 X 10^-4
	4 ft.	5.12	0.012	0.004	4.8 X 10^-5	4.8 X 10^-8	10	1.8 X 10^-4
7	2 ft.	5.06	0.013	0.005	6.5 X 10^-5	6.5 X 10^-8	10	2.4 X 10^-4
	4 ft.	5.54	0.013	0.006	7.8 X 10^-5	7.8 X 10^-8	10	2.8 X 10^-4
10	2 ft.	4.60	0.011	0.004	4.4 X 10^-5	4.4 X 10^-8	10	1.6 X 10^-4
	4 ft.	4.17	0.013	0.004	5.2 X 10^-5	5.2 X 10^-8	10	1.9 X 10^-4
12	8 ft.	4.39	0.004	0.003	1.2 X 10^-5	1.2 X 10^-8	10	4.4 X 10^-5

Fig. 6: The draft is perplexing

Fig. 7: some electricity can be produced, but not much!

TABLE 3: ENERGY PRODUCED BY DEVICE WITH DOORS CLOSED

MAP LOC	HET ABOVE GRD	AVE VOLTAGE (V)	AVE CURRENT (A)	POWER (W)	POWER (kW)	AVE HOURS PER DAY	ENERGY PRODUCTION PER DAY (kWh)	ENERGY PRODUCTION PER YEAR (kWh)
6	2 ft.	0.010	0.004	4.0 X 10^-5	4.0 X 10^-8	14	5.6 X 10^-7	2.0 X 10^-4
	4 ft.	0.011	0.004	4.4 X 10^-5	4.4 X 10^-8	14	6.2 X 10^-7	2.3 X 10^-4
7	2 ft.	0.008	0.003	2.4 X 10^-5	2.4 X 10^-8	14	3.4 X 10^-7	1.2 X 10^-4
	4 ft.	0.009	0.004	3.6 X 10^-5	3.6 X 10^-8	14	5.0 X 10^-7	1.8 X 10^-4
10	2 ft.	0.011	0.004	4.4 X 10^-5	4.4 X 10^-8	14	6.2 X 10^-7	2.2 X 10^-4
	4 ft.	0.010	0.003	3.0 X 10^-5	3.0 X 10^-8	14	4.2 X 10^-7	1.5 X 10^-4
12	8 ft.	0.002	0.002	4.0 X 10^-6	1.2 X 10^-9	14	5.6 X 10^-8	2.0 X 10^-5

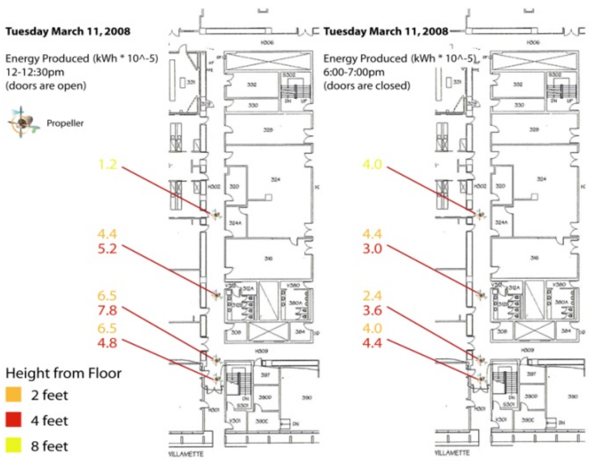

Fig. 8: Diagrams of energy produced by device.

5. <u>DATA ANALYSIS</u>

The wind energy that we harvested does not produce much electricity, about .46 Watts per year at the location with the highest wind speed. That means it would take about 130 and a half years to produce 60 Watts. Though the wind speed is uncomfortable (it reaches up to 11 miles per hour at one point) it does not flow fast enough to produce significant amounts of energy. Also, our device is quite small, only two feet in diameter and only has two propellers, so it is not that efficient as a power generator.

6. <u>CONCLUSION</u>

The air speed in Klamath Hall is enough to generate 60 W of power, only it would take one hundred and thirty years. Our hypothesis was proven, though the result is extremely impractical. This can be remedied by making the wings of the wind generator longer or using a higher quality motor. This would increase the potential for energy, but is unlikely to produce enough energy to be useful. Further, if the device was made any larger, its placement in the hallway would block all circulation.

We had high hopes for this experiment; we thought we could make a difference. It turns out that little can be done to convert the wind speed in the hallway into something useful – it will continue to be a source of discomfort without performing any practical function. While the Klamath Hall project is a dead issue, the idea can still be used in any other building where drafts occur. Perhaps there is a place where there is plenty of room for a wind generator and where the wind travels fast enough to produce significant electricity. It can be done, and it can make a difference.

7. <u>DESIGN LESSONS LEARNED</u>

To design a building well, it is necessary to know its function. At Klamath Hall, the mechanical system seemed to be placed without considering the way the classrooms were to be used: this is wrong. We interviewed several people during the case study asking why they thought the draft was coming through the hallway and one responded, simply, “because the building sucks.” Our job as architects is to ensure the comfort of those who inhabit our buildings or the architecture will be criticized, and rightfully so. The hallway is never in a comfortable state – the draft blows one's hair; it causes posters to rattle noisily and this is unacceptable.

Another lesson learned is that, if a building needs to be modified and an excess of energy is created, one should take advantage of this. To salvage this unused energy can be extremely beneficial; imagine lighting an entire classroom with energy that would never be used anyway. That would be great! This experiment is helpful for our future design projects – next time we design something in studio, we will pay close attention to the function of the building and the needs of its users so as to reduce any amount of wasted energy. Further, if we need to retrofit a building in the future, we will surely do so thoroughly to ensure there are no unintended, negative side effects.

8. ACKNOWLEDGEMENTS

Thank you,
Jake Keeler, our Graduate Teaching Fellow, for having high hopes for our project and offering moral support in the form of encouraging notes on our interim submissions.

The scientists of Klamath Hall for helping us understand pertinent design issues as they relate to the users; and for giving us information about the ventilating hoods in the classrooms.

Jason (April's Boyfriend) for providing us with a voltmeter and teaching us how to use it.

Alison Kwok for letting us use her plastic bubbles and for assigning this project. We are better because of it.

5. REFERENCES

1. http://www.otherpower.com/toymill.html
   For information on how to make our wind power generator and basic information on DC motors.

2. American Wind Energy Association;
   http://www.awea.org;
   We accessed the site for general information on the amount of wind and the size of a device to produce electricity.