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## Green Is the New Purple



**Figure 1. Sewall House.**

For my individual project I chose to study the possibility of creating a carbon neutral dorm. This means that a residential building on campus would have a net zero carbon emissions rate. In order to tackle this project I decided to focus my efforts on Sewall House (Figure 1). Sewall is one of the smaller houses in the Dodd Quad. The College purchased the house in 1974, it has 3,000 square-feet, and there are eleven residents currently living there. The appliances and main sources of energy use are the appliances that require electricity including the refrigerator, oven, stove, microwave, washer/dryer unit as well as heating for the house. Sewall is an appropriate house to begin with because it is small and already on the real-time metering for electricity, facilitating accurate emissions calculations. Additionally, since there are only eleven residents, if offsets had to be purchased it might be easier to convince 11 people to purchase

offsets than it would be to convince 50 students. Also, with a smaller number of people it is easier to lower energy use if everyone rallies together, whereas motivating fifty students to reduce their energy use might be more difficult. In a small house, people can easily see the affects of certain life style changes whereas in a bigger residence, the efforts of one energy saver could be eclipsed by a suite full of energy hogs. With fewer people it is easier to hold others accountable for their energy-using habits.

### *Heating*

In order to determine how to make Sewall carbon neutral, it is necessary to analyze how much carbon dioxide the building is actually emitting. Sewall House's emissions derive primarily from heating and electricity use. While electricity use on campus is measured in real-time metering and thus easy to track by building, heating is recorded only at the campus steam plant. This makes calculating heat use by building difficult. Sewall receives heat from both the College's steam plant (Figure 2) as well as being on the Northern Steam Line, which runs through Poker

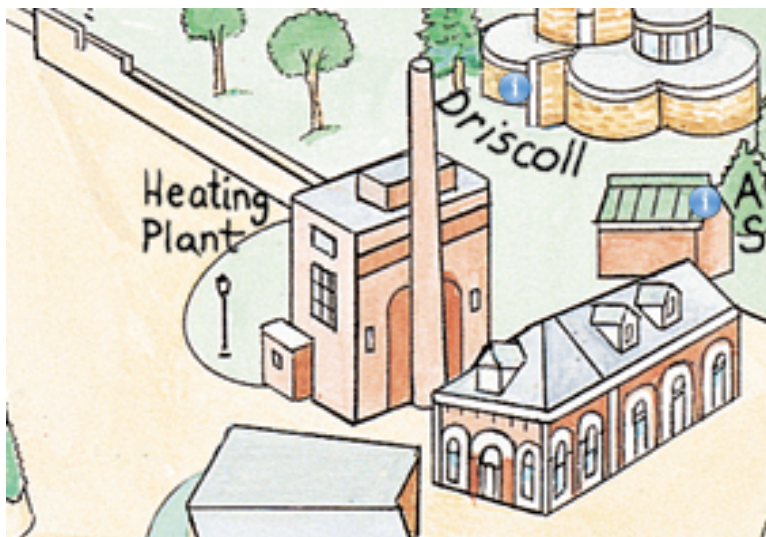


Figure 2. A representation of the College's Steam Heating Plant, located near Driscoll Dining Hall.

Flats (Williams Facilities).

Although the College replaced Sewall's heating system in 2008, it remains the largest contributor in the house's carbon emissions. It is possible to determine Sewall's approximate heat usage from the campus steam plant based on square-footage. Out of the total

1,777,883 ft<sup>2</sup> on the Williams campus that the steam plant heats, Sewall house comprises only

3,000 ft<sup>2</sup>, or 0.17%; thus, we can estimate that Sewall House also uses 0.17% of the steam plant's heat. This estimate does not take into account the variability of actually heating needs for each building, because Sewall may be using more or less than its proportion of steam heat depending on time of year and type of windows and insulation, among other factors.

Using a scale of 0.17%, however, one can calculate the amount of carbon dioxide emissions that Sewall is generating through heating. From March 2007 to March 2008, the steam plant burned a total of 373,483 MMBTUs of both natural gas and residual oil, emitting 56,954,392 lbs of CO<sub>2</sub> (Johns 2008). If Sewall uses 0.17% of the steam plant's production, then it accounted for 634.9 MMBTUs from March 2007-March 2008, equivalent to 96,882.3 lbs of CO<sub>2</sub> through heating (Table 1).

Table 1. Comparison of heat use and carbon emissions between the College's Steam Heating Plant and Sewall House for March 2007-March 2008. Sewall House used roughly 0.17% of the Steam Plant's heat.

	<b>Steam Plant</b> <i>(MMBTUs)</i>	<b>Steam Plant</b> <i>(lbs of CO<sub>2</sub>)</i>	<b>Sewall House</b> <i>(MMBTUs)</i>	<b>Sewall House</b> <i>(lbs of CO<sub>2</sub>)</i>
<b>Natural Gas</b>	130,683	15,289,911	222.16	25,92.7
<b>Residual Oil</b>	242,800	41,664,480	412.76	70,829.6
<b>Total</b>	373,483	56,954,392	634.92	96,882.3

### *Electricity Use*

Electricity use is a more precise indicator of carbon emissions in Sewall House, because it is metered in real-time, and results can be monitored daily. This is helpful in analyzing trends of electricity use during days, months, seasons, and years, and in helping cut electricity use as part of reducing overall carbon emissions.

In fiscal year 2007, the College used 26,782,161 kilowatt-hours of electricity. In comparison: from March 2007 to March 2008, Sewall used 9,569 kilowatt-hours of electricity—3.19 kilowatt-hours/ft<sup>2</sup> (Figure 3). That's barely .04% of the total electricity use of the College—

a low figure compared with other campus buildings. Because Sewall House is a relatively small producer of carbon, it is a strong candidate for moving toward carbon neutrality, requiring changes on a smaller scale compared with a larger producer. At the same time, Figure 3 shows that Sewall is also a representative carbon emitter as its electricity per square foot falls in the middle of a sample of campus residences: Goodrich House, adjacent to Sewall, Parsons House, Hubbell House, and Morgan Hall.

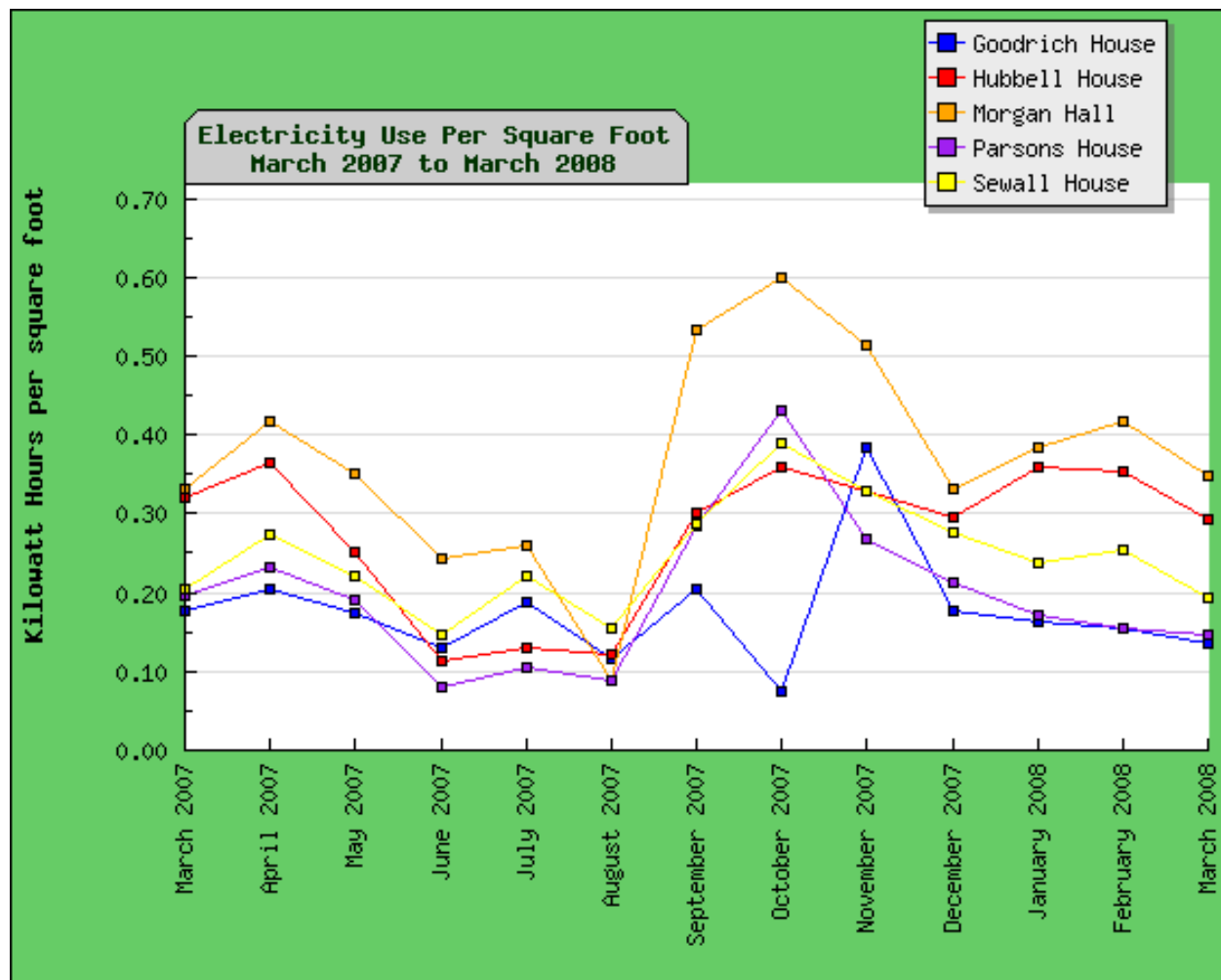


Figure 3. Electricity consumption per square foot for five campus residences from March 2007-March 2008. Although smaller than the other houses, Sewall House--represented by the yellow line--consumes a comparable amount of electricity per square foot as Hubbell and Parsons house.

As noted above, Sewall used 9,569 kilowatt-hours in one year. In order to convert electric energy into carbon dioxide, I used the U.S. Environmental Protection Agency's "Greenhouse Gas Equivalencies Calculator," and came up with 7.4 metric tons or 16,320 lbs of CO<sub>2</sub> annually. According to the EPA's website, 16,320 lbs of CO<sub>2</sub> is equivalent to the annual greenhouse gas emissions from 1.4 passenger vehicles, the emission from 17.2 barrels of oil consumed, the amount of carbon sequestered by 190 tree seedlings grown for ten years, the CO<sub>2</sub> emission from 308 propane cylinders used for home barbeques, the emissions avoided by recycling 2.6 tons of waste instead of sending it to a landfill, or the amount of carbon sequestered annually by 1.7 acres of pine or fir forests.

Combining Sewall's 16,320 lbs of CO<sub>2</sub> of to yearly electricity use with the 96,882.3 lbs of CO<sub>2</sub> due to heating, Sewall emits a total of 113,196.3 lbs or roughly 51.3 metric tons of CO<sub>2</sub> annually. The residents of Sewall House could do better. Sewall has the capability of being carbon neutral and an example for other dorms on campus. A house can reach carbon neutrality in two ways: by achieving net zero energy use or purchasing carbon offsets.

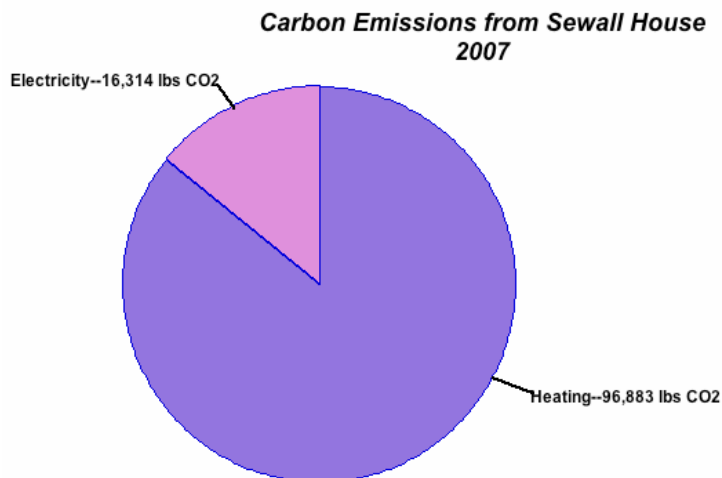


Figure 4. Breakdown of carbon emissions for Sewall House by heating and electricity. Heating accounts for roughly 85% of emissions and electricity accounts for roughly 15%.

### *Net Zero Energy Use*

For a house to be truly net zero, the carbon emissions generated by on-site or off-site fossil fuel use are balanced by factors such as on-site renewable energy production, on-site reduction of CO<sub>2</sub>, and purchasing of RECs and carbon offsets. One of the most obvious ways that a house like Sewall could reduce its carbon emissions would be to decrease the energy requirements for heating. (Sewall does not have any cooling or air-conditioning.) Unfortunately, because Sewall is not going to be renovated in the near future, many structural problems with Sewall cannot easily be fixed; however, poor insulation wastes a great deal of energy and could

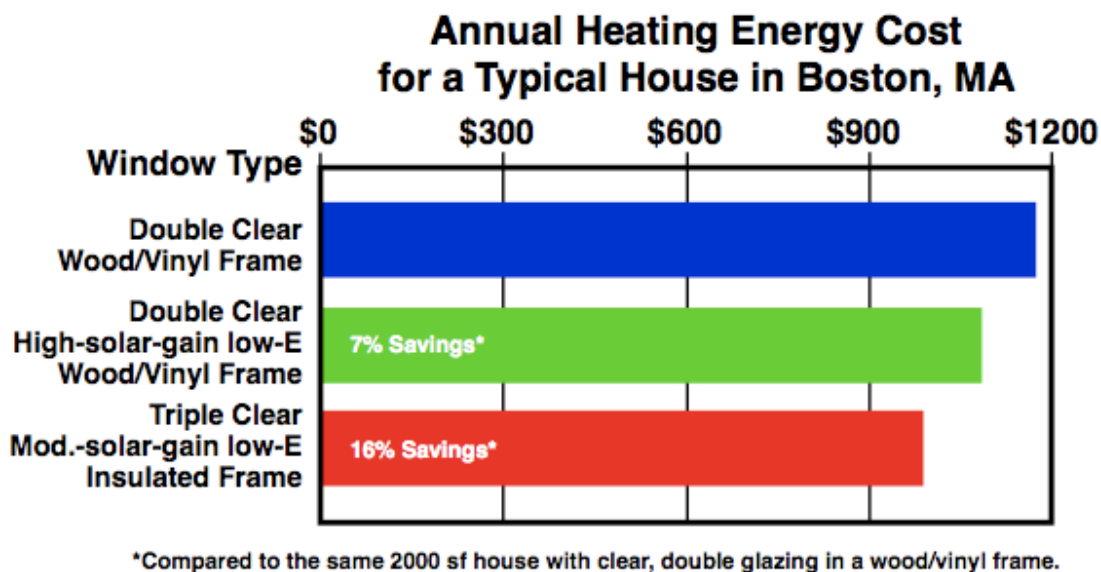


Figure 5. Annual heating energy cost for a typical house in Boston, MA. A significant savings on heating costs is possible over time through the replacement of old windows with newer, more energy-efficient ones shown above.

certainly be improved, as could the windows. The heating season in Williamstown is significantly longer than other places in the United States. Windows can be a source of significant unwanted heat loss and thus significant unwanted energy use and carbon emissions. The College probably would not be able to replace the windows and window frames altogether,

but they could invest in window glazing, which would significantly reduce heating costs (Figure 5). According to the Efficient Windows Collaborative's, "Builder Toolkit": "For a typical 2,000 ft<sup>2</sup> house in Boston, Massachusetts, double-glazed Low-E windows instead of conventional double-pane windows reduce heating costs by 7%. Triple-pane Low-E windows with insulated frames would save as much as 16%," (Efficient Windows Collaborative). Furthermore, if the holes and cracks in the floor, walls, and ceiling were fixed, heating of Sewall could be made more efficient, lowering carbon emissions.



Another option for Sewall would be to consider adding a solar hot water pre-heat system, which is a backup water heater so we would not have to waste as much energy heating our water. Because Williamstown has a fairly cool climate with unreliable sun a solar water heating system with active, evacuated tubes would be the most beneficial (Figure 6). Those usually fall between \$ 6,000 to \$17,000 (Solar

Direct). Factors such as the emissions resulting from producing the solar hot water system from raw materials and the initial cost of installation should be taken into consideration.

Another—less invasive—step toward reducing Sewall's emissions would be replacing the refrigerator with an Energy Star<sup>®</sup> model. Currently, the refrigerator is a Crosley<sup>®</sup> Shelvador and according to the Energy Star<sup>®</sup> website, it uses approximately 716 kilowatt-hours annually.

That makes up for 7.5 percent of Sewall's annual electricity use. This could be decreased by switching to a new Energy Star® refrigerator. In fact, the website claims that replacing Sewall's refrigerator with a new, more efficient one, would save over \$40/year, because it would only cost \$53 per year to operate whereas our current fridge costs \$92 per year. These estimates are based upon the Williams College price of \$0.129/kW hour. At this rate, the College would be able to pay off the new refrigerator, costing approximately \$1,100, after 28 years. Additionally, if Sewall is on its way to becoming carbon neutral, it should be mandatory that no residents use their own miniature refrigerators. These are unnecessary given that there is a full-sized refrigerator/freezer downstairs in the kitchen that can accommodate all eleven residents. While the Maytag® front-loading laundry machines are already efficient, the Crosley® oven/stove top could be replaced with a new Energy Star® model as well.



Figure 7. A representative PV pole array in a wooded area similar to the Dodd Circle.

Perhaps the most powerful yet least likely way that Sewall could move toward carbon neutrality would be by installing a photovoltaic system. Because Sewall does not have a flat roof and because the house is so small, photovoltaic (PV) panels would probably not be able to fit on the roof itself;

however, mounting PV panels on a pole, which would then connect to Sewall and surrounding buildings is an option (Figure 7). Also, tall oak trees heavily shade Sewall itself, which means that the solar panels would not be very efficient even on the sunniest of days. Pole-mounted arrays seem much more feasible for the College because they do not affect the roofing, and they can be oriented due south to receive maximum sunlight. PV shingles, which are in the early stages of development, are also viable. Producing energy at its maximum capacity, The PV array on Morley Science Center can generate 57.6 kilowatt-hours of electricity per day (Sustainability at Williams). This alone could offset approximately 80 lbs of CO<sub>2</sub> in one day—more than three times the carbon emitted by Sewall’s daily use of electricity. In February 2008, Sewall used 764 kilowatt-hours of electricity. If Sewall was connected to an array that was producing as much kilowatt-hours on a regular basis as the array on Morley, it could offset significantly more than the current electricity use of Sewall.

Unfortunately, a PV array in Williamstown is not nearly as reliable as these figures would suggest. Although the Morley array can produce 57.6 kilowatt-hours of electricity in a day, this is the best possible rate. According to the Sustainability at Williams website, “...it would be highly unusual for a solar panel to produce at maximum capacity” (Sustainability at Williams). In fact the greatest output that the Williams array has ever had in a twenty-four hour period was about 50 kilowatt-hours, enough to offset 69.6 lbs of CO<sub>2</sub> (U.S. EPA). This rate is still more than twice what Sewall House emits through electricity use in one day; therefore, this size PV array could still cancel Sewall’s carbon emissions from electricity when producing at a lower capacity.

A final factor in considering a PV array is initial cost, which, if comparable to Morley, would be approximately \$70,000—\$10,000 per kW installed. While the impact for Sewall and

the surrounding houses would be beneficial, this is still a significant cost that requires a more detailed analysis to determine its practicality. If Sewall was one of the new buildings undergoing construction right now, it would be much easier to make it net zero because you would have those elements in mind during the planning process. Unfortunately, Sewall is an old house and so retrofitting it to be net zero is a much more difficult task because a lot of the new technologies cannot be integrated into the building after the fact.

### ***Carbon Offsets***

Fortunately, renewable energies are not the only solution for going carbon neutral. While exchanging appliances, searching for new energy sources, and making adjustments in one's lifestyle forces people to account for their own carbon footprint, it is often difficult to cancel total emissions in this manner. This is where carbon offsets become useful. When one purchases carbon offsets, he or she is investing in renewable energy projects that "reduce global warming pollution *on your behalf* by reducing the amount of power generated by burning fossil fuels," (Native Energy). A portion of the money accrued through the purchase of carbon offsets fuels the market for renewable energies. For each kilowatt hour of carbon offsets purchased, one kilowatt hour of energy generated by a fossil fuel plant is replaced by one kilowatt hour of energy generated by a new, renewable source that wouldn't exist without the new investments (Native Energy).

When individuals, businesses, or organizations purchase carbon offsets, they likely purchase "Renewable Energy Credits (RECs)". A simple way of thinking about RECs, as explained on the Native Energy website, is as follows: In exchange for investing a small amount of money extra each month in his or her utility company to include wind power, an individual

will receive credits. These credits can be used to offset the individual's emissions that they cannot avoid—air flights, for example. Alternatively, the College could also choose to buy RECs from an REC supplier, such as Native Energy, whom they have already purchased from in the past (Scene and Herd).

The main difference between RECs and carbon offsets is that offsets must actually counterbalance the amount of emissions being produced—by coming from a project implemented with the money spent on the offsets. RECs, while entitling the individual who purchased them to say that he or she produces less carbon dioxide pollution, in essence support other renewable sources of electricity. While RECs are limited to electricity producers, offsets can come from projects, which reduce fossil fuels, stop emissions of methane, or sequester carbon in preserved forests (Native Energy).

At present both RECs and carbon offsets are relatively new and thus not always reliable, because the market is currently unregulated. This lack of control makes many people nervous about investing in renewable energies--especially RECs--which are tradable commodities. In spite of these risks, the College did take a chance on carbon offsets for Commencement last May when they purchased \$8,600 in global carbon offsets from Native Energy to offset the carbon dioxide emissions created by operating the campus as well as by families and friends traveling to Williamstown for the event. The offsets accounted for what they approximated to be 818 metric tons worth of CO<sub>2</sub> (Scene and Herd).

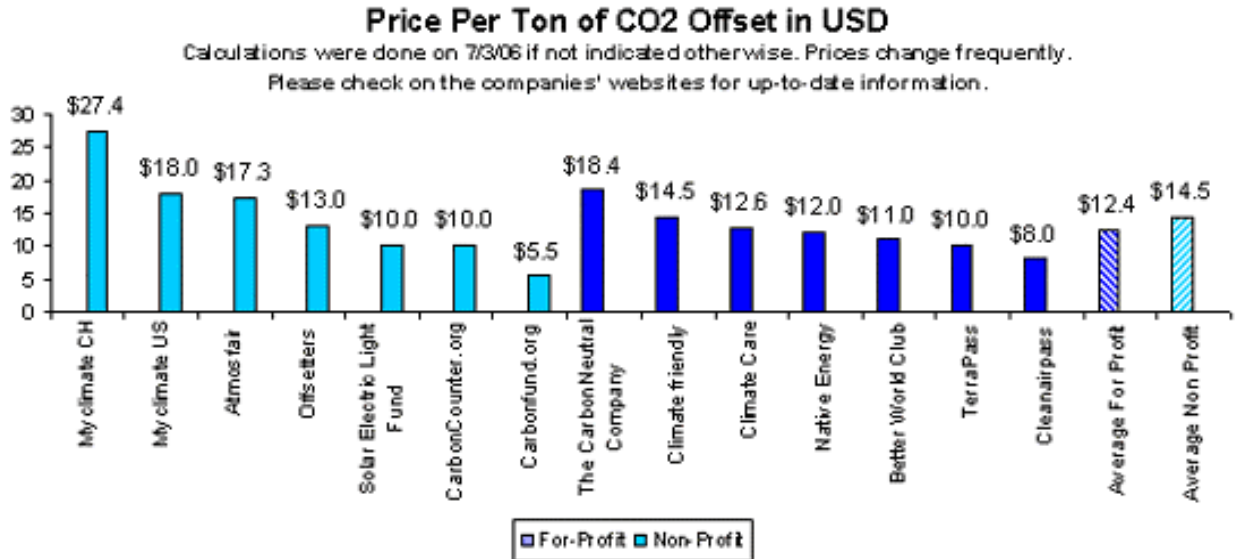


Figure 8. Range of prices per ton of carbon offsets—indicating less stability in the new market.

Figure 8 illustrates the price range of carbon offsets. Most carbon offsets fall between \$5 to \$35 per metric ton of CO<sub>2</sub> depending on who is selling the offset (Tufts Climate Initiative). This means that for Sewall to offset its current carbon emissions of 51.3 metric tons by purchasing offsets, it would have to pay between \$256 and \$1,795 each year.

Given the many ways that Sewall could reduce its current energy use, this cost could be even lower. This project could definitely be feasible for next year's Sewall residents. Each year the Dodd Neighborhood Governance Board allocates funds for each house. The Baxter Fellow in each house is responsible for using those funds in a way that the house approves. I think that the money for each house could be used towards offsetting the residents' energy use. Of course this decision would have to be made by the residents themselves, but it seems like a simple way to reduce their carbon footprint. And again, purchasing carbon offsets should not be an excuse for polluting. First and foremost, the residents of Sewall House must assume the responsibility for reducing their emissions through more deliberate lifestyles and pressure on the College to make more eco-friendly investments.

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#### Figure 8:

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