Reed College Climate Impact Assessment

Reducing Reed's Carbon Footprint, One Watt at a Time

Environmental Studies Junior Seminar, May 2015

Goals of this Report

Reed College has both the means and the responsibility to pursue rigorous sustainability goals. In order to make the institution a more sustainable, resourceful, energy efficient school, we hereby present a collaborative, data-driven Climate Impact Assessment. With the hope of educating students, faculty, and staff about their individual impact on Reed's carbon footprint, we have compiled data on campus-wide electricity use, along with maps in order to spatially demonstrate variations in energy expenditure. With this information, we have recommended next steps and provided tools with which to achieve these goals. By aiming to inspire behavioral change, we hope to increase public awareness of the connection between our actions as a community and climate change.

Final Report of the Spring 2015 Environmental Studies Junior Seminar (ES 300) at Reed College

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With support from the Environmental Studies Program at Reed College

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1. Introduction: Sustainability at Reed

1.1. Reed's Sustainability Mission

> **"Reed College is committed to responsible stewardship of its campus environment and is aware that our actions and decisions impact our city, our region, and our planet. As an institution of higher learning, Reed is dedicated to investigating, understanding, and promoting awareness of its present and future impact on the natural world. Through broad community involvement and education, Reed strives to incorporate ideals of sustainability into the operations of the College and the daily lives of individuals on campus. Sustainability is commonly accepted to mean meeting the resource needs of the present without compromising the ability of future generations to meet their needs. All Reed efforts in support of sustainability will strive to maintain and develop the College in a responsible manner and to minimize the College's impact on the environment."**

(Faculty Handbook, 2008). Approved by the Faculty December 4, 2006 and the Board of Trustees February 10, 2007

Sustainability initiatives have been an integral part of Reed's mission for many years, and they continue to reflect the school's dedication to the environment. In 2013, Reed signed a three-year, $5.4 million contract with Ameresco Quantum, in order to reduce on-campus energy use and improve the sustainability of pre-existing facilities. The agreement is projected to result in more than $250,000 in energy, water, and maintenance savings. Home to a 28-acre canyon, Reed has also invested in several restoration efforts to sustain the wildlife and plant life that inhabits the unique watershed. These efforts include, but are not limited to, invasive pest management, leaf recycling, drip irrigation, use of organic fertilizers, use of eco-lawn mixes, and a preference for native plants. The Reed Canyon is an invaluable source of beauty and nature for students and staff. Zac Perry, our canyon restoration manager, along with a passionate group of students, works tirelessly to keep the preserve healthy and accessible for members of the community to enjoy. Along this philosophy, Reed's oldest tradition, dating back to its founding days, is Canyon Day, a day once a semester where community members restore Reed Canyon by picking up litter, getting rid of unwanted plants, and creating a healthier environment for native plants.

Reed has also proven to be a proponent of sustainable food practices, and it has chosen Bon Appétit as its independent food service contractor. Bon Appétit, which was the first food service company to publicly establish the connection between food choices and climate change, was awarded a Gold Sustainability Award in 2014 through Portland's Sustainability at Work Program.[1] Bon Appétit values small farms, local ingredients, cage-free eggs, antibiotic and hormone-free meat, biodegradable products, and composting, amongst other environmentally sound methods of food production. In addition to Bon Appetit's overall sustainable practices, students have successfully incorporated mostly meatless Mondays into the food schedule and have a waste management program designed to cut down on waste.

Additionally, Facilities Services works under the constant goal of attempting to increase efficiency and comfort whilst reducing net energy use. Efforts to improve the school's sustainability through facility use include low voltage lighting, motion detectors, low flow sink nozzles, low volume toilets, preventative maintenance check-ins, air conditioning and heating limits, and use of low-VOC paints. With regards to transportation, Reed incentivizes its community to support sustainable practices by providing subsidies for TriMet passes, allotting bicycle parking, limiting the number of school-owned vehicles, and limiting the number of parking spaces. Also, Reed has a

[1] http://reed.cafebonappetit.com/wellness/

Sustainability Committee, with students working as interns on projects to reduce the amount of waste generated through on-campus events and move-outs. Reed has created a paid student position for Sustainability Coordinator who is hired by the senate and paid by the student body. The person in this position works with members of the Sustainability Committee, facilities, professors, and students to create and carry out campus-wide projects. Students, faculty and staff alike have put their time and energy toward improving our sustainability efforts as a community. Small and large projects, spearheaded by students in collaboration with faculty and staff, have been created and successfully carried out.

In 2012, Reed launched an interdisciplinary Environmental Studies (ES) program, allowing students to major in Environmental Studies with a focus in biology, chemistry, economics, history, or political science. The coursework spans both the natural sciences and the social sciences, maintaining an environmental emphasis throughout all disciplines. Each year, junior ES majors participate in a semester-long seminar during which they explore topics relating to environmental change and global climate.

As Reed's 2015 Environmental Studies Junior Seminar, we are collectively committed to our role as environmental stewards both on and off campus. With the groundwork for a sustainable campus laid down before us, we hope to make the Reed community aware of its energy use and of subsequent impacts on the environment. We hope to situate our actions in the broader scope of global climate change and to provide an educational opportunity for the Reed community to learn more about sustainability on campus. Ultimately, we hope to encourage environmentally conscious, sustainable actions that will help our school continue to be resourceful and appreciative of the landscape we inhabit.

1.2. Assessing electricity use as a sustainability goal

This report puts a strong emphasis on campus-wide electricity use, investigating both where our energy comes from and how it is managed. Though the focus of this assessment is on electricity, an evaluation of water use and natural gas for heating could be valuable additions to campus-wide monitoring towards future sustainability efforts. Creating goals for the future is pertinent, as it will keep the college on an enduring path toward carbon neutrality and overall environmental responsibility. As previously mentioned, we have already started this journey, teaming up with Ameresco and making changes such as switching to more efficient light bulbs, and water saving toilets and showerheads. Facilities monitors the amount of energy each meter uses and where that energy comes from. About one-fifth of the school's electricity comes from sustainable solar panels, and our new Performing Arts Building was constructed solar panel-ready.

This document provides a comprehensive summary on current energy saving initiatives, student behavior, structures in place to improve Reed's sustainability, and goals for the future of Reed College. First, this document discusses the nature of the electricity we use on a daily basis, a brief history of PGE, and behavioral electricity use of Reedies. This section outlines the rise of the electric lifestyle, how much power we get from which sources, and most importantly, what these percentages would look like if we approached our energy purchasing with more renewable energy in mind. It also specifies the sources of these energies and the costs and benefits associated with them. Next, we summarize the work Ameresco Quantum has done for the college, and we provide a comprehensive breakdown of the changes made in each building, as well as the energy saved. Energy efficiency and sustainability is not the sole responsibility of facilities, however: we explicitly outline the amount of energy typical devices use, based on our own research, from laptops and phone chargers to encourage individual behavior change. Finally, we offer some goals and recommendations for the future, how we can make meaningful changes to diminish our negative impact on the climate.

2. Electrified Portland: Portland General Electric and Reed

Reedies are plugged in. From the near silent hum of our computer labs, with the quiet clicking of human digits on plastic keys, to the raucous Stop Making Sense - cranked up and projected ritualistically each year - we are an electrified community. Reed was founded in the early 1900s, right around the time that electricity started flowing to homes and businesses in Portland. This electricity was then and is today provided by Portland General Electric (PGE).

As the US began to generate power and build the electric grid, many places supplied electricity only at night as it was used primarily for lighting. Some potential users needed to be convinced of its usefulness beyond lighting. "PGE encouraged the use of electricity in the home and marketed the 'labor saving devices' that required it."[2] The company promoted irons, fans, sewing machines and the like. "From 1909 to 1938 the first floor of the Electric Building featured a retail store selling electric appliances and maintenance services. Retail sales were slow initially because many homes lacked

[2] Portland General Electric Exhibition: Oregon Historical Society March, 2015

outlets"[3] In the mid 1950s, PGE started advertising all-electric homes. The company began participating in a national program, launched by the Edison Electric Institute. The program was designed to promote the use of electricity to builders and homeowners. "By the end of the 1950s, the average PGE customer used three times the national average of electrical energy."[4]

Getting Portlanders, and by extension Reedies, to use a lot of electricity took a concerted effort by a consortium of electricity providers. This behavioral change was encouraged through the promotion of an electrified lifestyle and cheap electricity. Through a careful study of our energy consumption both historically and today we can strategize a plan to reduce electricity use at Reed. Today PGE serves 52 cities within 4,000 square miles offering a residential price per kilowatt-hour at about 10 cents less than the national average. We are still getting relatively "cheap" electricity, but only when we fail to consider the ecological cost of our consumption.

A close look at our power distribution, when we include purchased power reveals that about half of our electricity comes from burning fossil fuels (Table 1). A full 30% of our electricity is provided by coal fired power plants, some of the dirtiest energy available. Close to 20% is provided by natural gas. Both of these fossil fuels create greenhouse gas emissions contributing to global warming. While 41% of our electricity comes from hydropower, which does not contribute to greenhouse gas emissions, there is ongoing substantial harm to wildlife, ecosystems, and a legacy of environmental racism associated with the dams that make this power available. Very little of our PGE provided electricity comes from wind and solar, but Reed produces some solar energy

[3] Ibid
[4] Ibid

via panels on the roofs of the facilities warehouse. This essentially offsets the electricity use of the warehouse buildings.

Table 1. Sources of PGE electricity. An asterisk indicates a plant wholly owned by PGE; the remainder are jointly owned.

Type	Name / Location	Megawatt Capacity
Hydroelectric	Faraday* / Clackamas River	46
Hydroelectric	North Fork* / Clackamas River	58
Hydroelectric	Oak Grove* / Clackamas River	44
Hydroelectric	River Mill* / Clackamas River	25
Hydroelectric	T.W. Sullivan* / Willamette River	18
Natural Gas/Oil	Beaver / Clatskanie, OR*	516
Natural Gas/Oil	Coyote Spring / Boardman, OR*	246
Natural Gas/Oil	Port Westward / Clatskanie, OR*	410
Wind	Bigelow Canyon Wind Farm[5] / Sherman Co., OR*	450
Coal	Boardman[6] / Boardman, OR	374
Coal	Colstrip 3 & 4[7] / Colstrip, MT	296
Hydroelectric	Pelton[8] / Deschutes River	73
Hydroelectric	Round Butte / Deschutes River	225

TOTAL: 2,781 MW

Power Purchase Agreements[9]

Vansycle Ridge Wind Project, Umatilla County, 25 MW
Klondike II Wind Project, Sherman County, 75 MW
Disptachable Standby Generation 80 MW

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[5] For wind-powered generating facilities, nameplate ratings are used in place of net capacity. Portland General Electric Website: Power Plants.
[6] PGE operates Boardman and has a 65% ownership interest. Portland General Electric Website: Power Plants.
[7] PPL Montana, LLC operates Colstrip 3 & 4; PGE has a 20% ownership interest. Portland General Electric Website: Power Plants.
[8] PGE operates Pelton and Round Butte and has a 66.67% ownership interest. Portland General Electric Website: Power Plants.
[9] PGE remotely starts, operates and maintains customer-owned, standby generators for system operating reserves and peak load management. Portland General Electric Website: Power Plants.

The following pie charts, obtained from PGE, show that purchased power (Figure 1), as well as the power Reed chooses, can have substantial impact on the amount of environmental harm our power use incurs. The largest portion, 35% of the energy that PGE sells to Reed is purchased power (Figure 2). PGE owns major transmission rights to Pacific Intertie. This allows for power exchange between other utilities based on demand and production. It is possible for Reed to opt into Clean Wind, a billing option that adds an extra fee for new wind development, or Green Source which promises to offset all electricity usage with renewable energy. PGE's description of the Green Source mix (Figure 3) for 2015 states, "this product will come from approximately 98 percent new wind, 1 percent new geothermal and 1 percent new solar energy." By choosing Green Source an electric bill of $1,000,000 per year (about what Reed pays) would rise to $1,101,634.

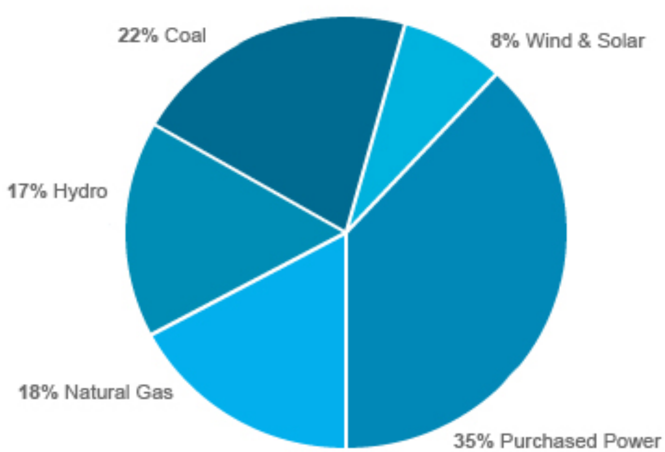


Fig 1. 2013 power sources as a percent of retail load.

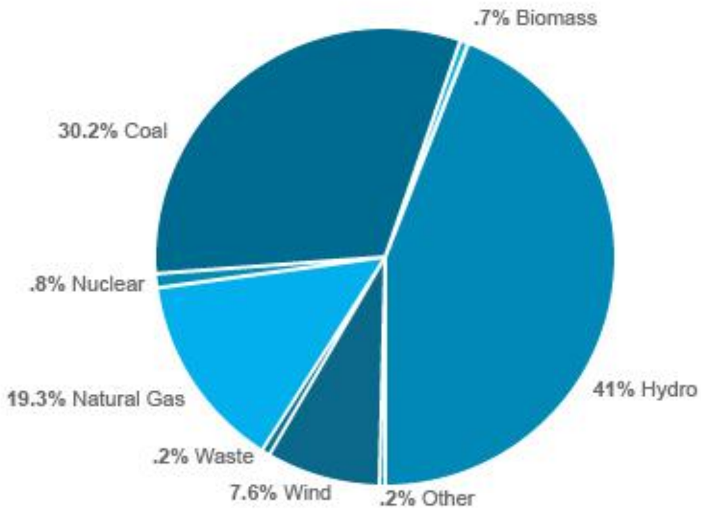


Fig 2. 2013 power sources including purchased power.

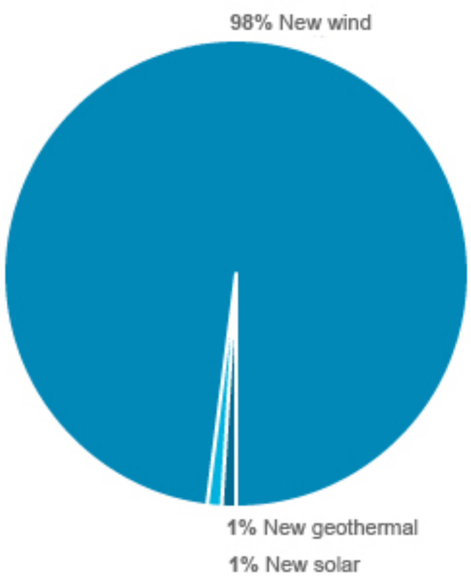


Fig 3. 2015 Green Source Power Mix.

3. Ameresco Quantum Energy Assessment

In 2013 Reed signed a $5.4 million contract with Ameresco Quantum, an energy services company, to identify and execute changes to reduce energy use while maintaining building livability. Ameresco assessed energy use across the Reed campus and began various retrofits guaranteeing that the resulting savings would "produce over $250,000 annually in energy, water and maintenance related savings; equivalent to CO2 emissions reduction of 2,647,750 pound per year."[10]

Ameresco reports that they have completed 95% of the projects at Reed totaling around $6 million. While we do not have exact completion dates for various buildings we have been able to use their guaranteed energy savings with the data we have for past electric use to project usage in individual buildings that have received upgrades. Figure 4 shows the projects savings estimated by Ameresco; this figure could be used to evaluate the effectiveness of these energy upgrades.

Ameresco's baseline Energy Use Analysis shows that between 2008 and 2010 Reed's average electricity use was 10,707,586 kWh with an associated cost of $871,800, our average natural gas was 658,272 therms with a cost of $544,280 and our water/sewer average was 30,253 CCF costing $269,575. For the purposes of this report, our focus will remain largely on electric use and work with estimated/guaranteed energy savings.

[10] Reed College Energy Services Project, documentation from Ameresco, courtesy Steve Yeadon

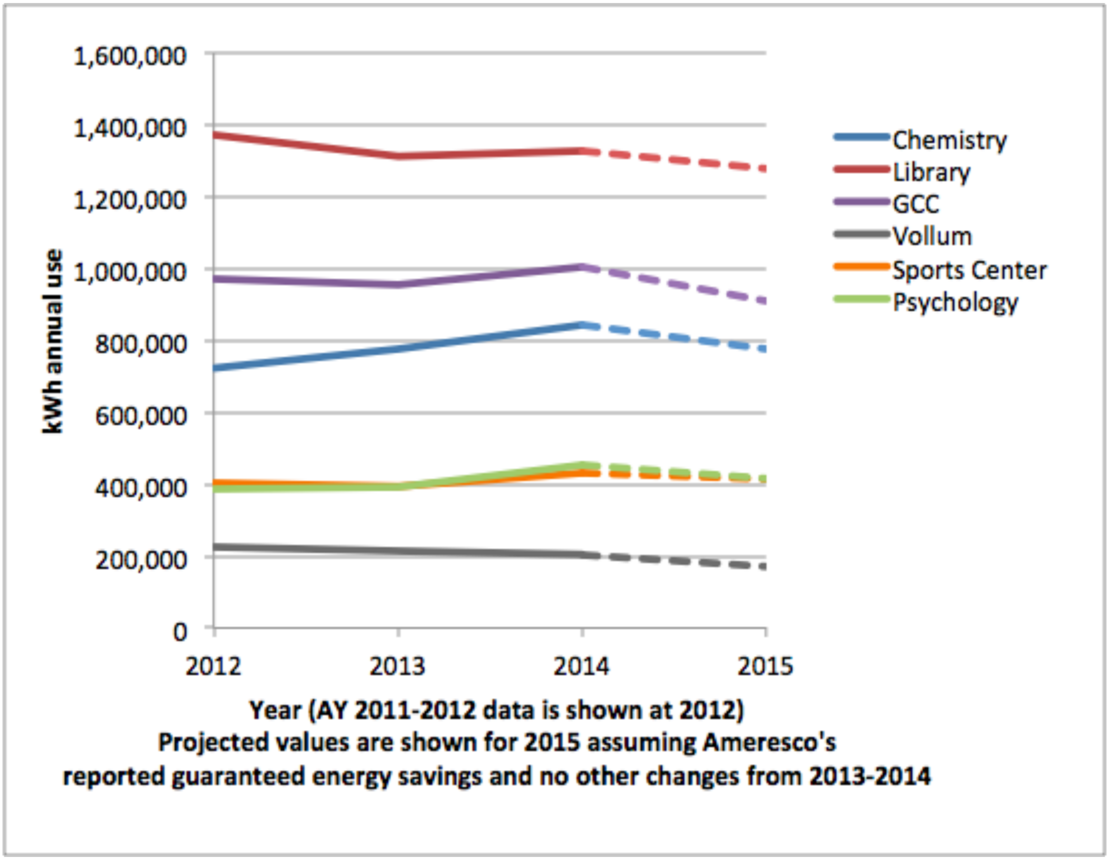


Fig 4. Projected energy savings per building based on Ameresco Quantum's guarantees.

4. Electricity Use at Reed

4.1. Individual Consumption

The nature and usage of electrical power on Reed campus is such that individuals have little control over total energy consumption. Academic buildings are illuminated and heated to standard amounts, and offices, support services, and Reed-owned buildings outside of campus, while contributing to total energy use, are outside the student's sphere of direct influence. It is because of this lack of direct influence on collective energy use that we must focus on individual energy use and how each person may directly reduce their energy consumption.

For individual energy use data collection we used the HOBO UX120 Plug Load Data Logger manufactured by onset®. Figure 5 shows sample output data from the logger using the HOBO software, demonstrating the obtained time-series of wattage, amperage, and kWh energy usage of the plug load. This device, similar in size and shape to a brick, can connect to appliances and wall outlets to measure Amps (A), Watts (W), Volts (V), and Kilowatt Hours (kWh). Affectionately called "The HOBO", the class used this in conjunction with a power strip to measure the wattage (W) and power (kWh) of several appliances over time. This was useful in understanding the general use trends of several people involved in the project, but it was determined that measuring each appliance by itself would produce more coherent data. All of the data for individual energy use was collected with this device. The HOBO is not only a powerful tool for quantifying power use, but also for qualifying trends in use. By connecting this device to your laptop, you can measure exactly how much energy is used when watching a movie versus editing a text document. The graphical output is a ready–made way of presenting information to the public and displaying how the minutia of electronics use patterns affect energy consumption.

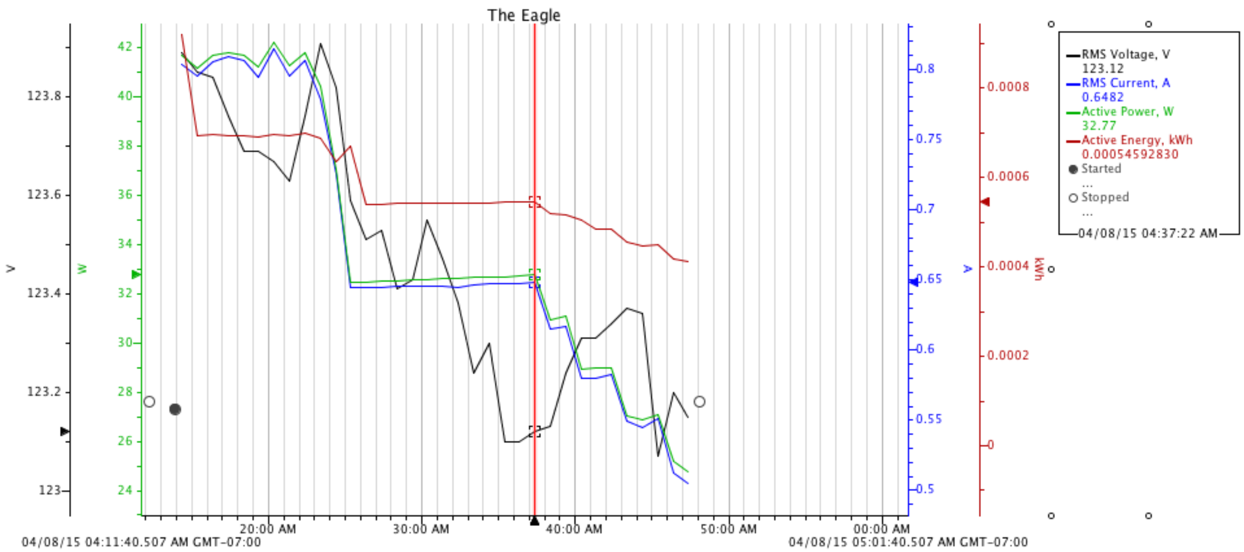


Fig 5. Energy and Power Use for 13" Macbook Pro collected over 50 minutes[11]

Table 2: Power Use for Apple Products

Appliance	**Full use, charging (W)**	**Rest use, charging (W)**	**Off, charging (W)**
Macbook Pro 13"*	38±1	25±1	21.2±0.1
Macbook Air 13"**	60±2	60±2	52.3±0.1
Iphone 5S	6.6±0.1	n/a	6.50±0.05

*Macbook Pro was charged at ~70% battery remaining

**Macbook Air charged at ~5% remaining

[11] The "Eagle" refers only to the graph file name. The red vertical bar shows instantaneous data for all measured values. Each of the four colored horizontal trend lines represents a different measured value.

The "full use, charging" standard was set to the maximum brightness, volume, and playing standards.[12] Data were recorded while the video was playing, then data were recorded after the Macbooks were put in "sleep mode" and allowed to rest for 5 minutes. The table shows the 13" Air uses much more power than the Pro, even though the Pro is larger and usually uses more energy. This is due to that fact that the Air is almost without a battery charge. Aside from the relatively high power usage by the Macbook Air in this dataset, it appears that when the computer is charging from a very low battery level, the change in its active state (on, sleep, off) does little to change power use. The Iphone, as expected, uses the least power because of its small screen and processor.

Table 3: Customer Contribution to CO2 Equivalent Emissions. According to Apple the larger the computer is, the more individual energy use contributes to the total lifetime CO2e released.[13]

Appliance	**Iphone 5S**	**Macbook Air 13"**	**Macbook Pro 13"**	**iMac 21.5"**
Consumer Emissions %	14	12	25	39

Apple provides information on the lifetime greenhouse gas emissions of each of their products via a percentage scale of carbon dioxide equivalents (CO2e) released during manufacturing, transportation, customer use, etc. Table 2 shows that with an increase in screen size and processing power, the customer contribution to greenhouse gas emissions increases. All the products listed are common on the Reed campus and the imac 21.5-inch desktops are used in the library, ETC, PARC, and other computer

[12] "ARRRRR Horse" Youtube video: https://www.youtube.com/watch?v=_oRSHFoRbiE
[13] Apple Co. Environment Reports.

labs all over campus. A way of reducing Reed's contribution to greenhouse gases would be to buy products with smaller screens, and keep those screens dimly lit.

Although it would be possible to provide some financial incentives for students, encouraging them to buy smaller, more efficient devices, the prices of apple computers are mostly set by the manufacturer and few take into account the CO2e emissions when buying a computer. Educating students on the most efficient devices and their personal contribution to climate change would hopefully help them make more environmentally conscious buying decisions.

Another possible area of improvement would be the addition of power strips to dorm rooms. The Tricklestar Powerstrip was used in determining the effectiveness of "smart" power strips and their stated functions. First and foremost, when measured with the switch set to "off" the power strip drew no power (0 W). There were two main observations.

1. "Threshold Level" did not change power available to any socket.
2. No power available to "slave" sockets while "master" socket is not in use.

These observations show that the powerstrip does perform as advertised, however, it should be noted that when "on" the powerstip uses 0.6±0.1 W with no load connected. This is due to the light that displays information about the state of the powerstrip, and the fact that two of the outlets in the strip are "permanently" on. Powerstrips, in general, are an easy way to reduce energy use. Instead of turning off appliances individually to try and reduce "phantom power use", the powerstrips allow the owner to easily turn off all their devices at once. The Tricklestar Powerstrip, and others like it, increase the effectiveness by allowing one socket to control many others and having "permanently" powered sockets for appliances which require continuous power.

4.2. Campus-wide Electricity Use

Assessing campus-wide energy usage is a helpful mechanism to further our understanding of Reed's carbon footprint and its overall impact on the environment. Using energy data from 2009-2014, measured in kWh, it is evident that the 2012-2013 school year had the lowest recorded energy use by an average of 559,000 kWh. Potentially affecting this decrease in energy was the addition of the Performing Arts Building in 2013, which contains numerous windows and skylights to minimize the use of artificial light, along with bioswales and an eco-roof designed to minimize rainwater runoff. In terms of overall building energy use, however, it is unrealistic to narrow our focus to simply one method of increasing sustainability. While it is difficult to standardize a single method of measuring energy efficiency across all buildings on campus, campus-wide electricity data nonetheless illuminates trends in our electricity consumption and sheds light on potential behavioral recommendations.

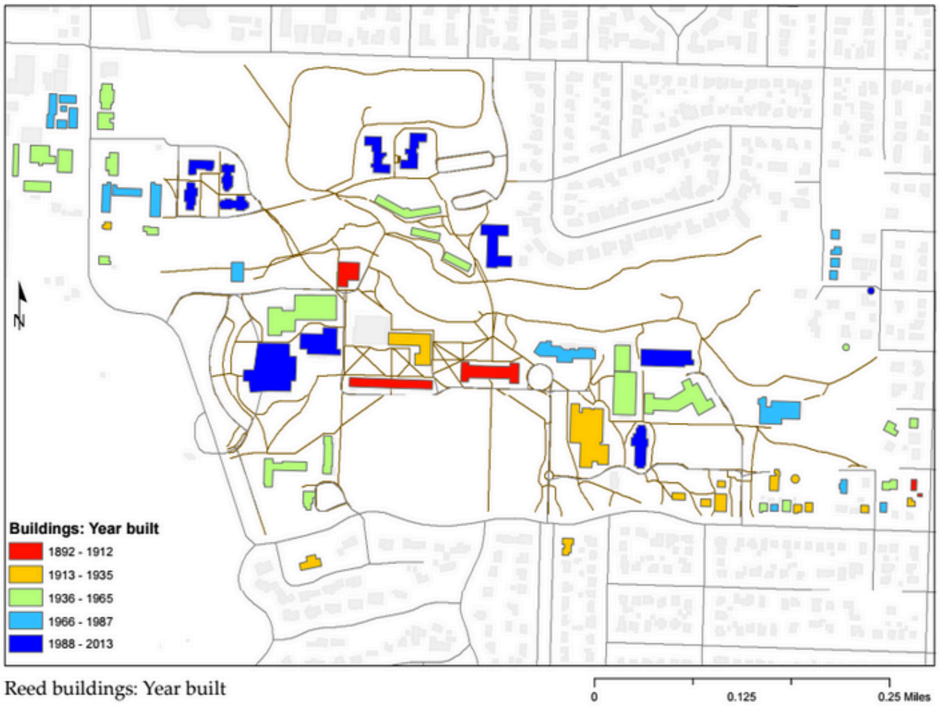
Excluding the Reed College Apartments and the Birchwood Apartments, both of which lie on the near edge of the campus' perimeter and use energy differently than dorm rooms, the average Reed resident student uses 1,910 kWh/year in her dorm. Taking into account both apartment complexes, the average resident student uses 2,190 kWh/year. Both of these evaluations assume maximum occupancy of all residential buildings.

Looking at data on the general distribution of energy across all on-campus buildings, several hotspots are immediately apparent. The joint biology and physics building uses significantly more energy than any other building on campus, with energy use an entire order of magnitude higher than that of other buildings. Additionally, residents in the Grove use three times as much energy as an average Reed resident student. Perhaps as a marker of perspective, the average Reed resident student uses less energy than the average American by a factor of five. These energy use distributions indicate several behavioral and lifestyle trends apparent on Reed's campus. In the Grove, student bedrooms each have individual thermostats, allowing residents the ability to use air conditioning or heat even when windows are open or when the weather does not require either function. This availability of thermostat control leaves room for inefficient behavior, potentially wasting energy and increasing the school's carbon expenditure and footprint.

As a method of further assessing the campus energy distribution, we analyzed reported electricity data from Reed's Facilities Services, and mapped the results using ArcGIS. Figure 6 depicts all on-campus buildings; with colors corresponding to the year that they were either built (top panel) or were renovated (bottom panel). These two figures are helpful in temporally situating all of Reed's existing buildings. Figure 7 depicts the amount of energy used annually by population in each dorm (assuming maximum occupancy), demonstrating a slight decrease in energy from the year 2011-2012 (top panel) to 2013-2014 (bottom panel). These figures clearly show that the Grove and the Birchwood apartments consume significantly more energy than other dorm groups on campus, but they also display a slight decrease in energy consumption in the Cross Canyon dorms and Bragdon Hall.

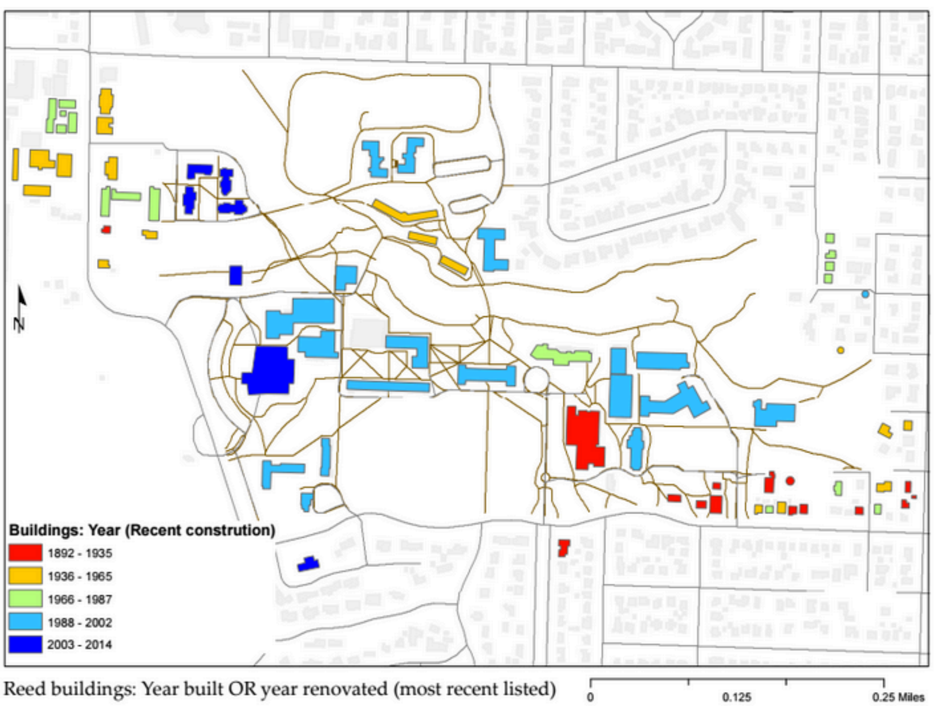
Figure 8 depicts electricity use in other, non-residence buildings on campus, including academic buildings, for the same two annual periods. One key feature is that the electricity use of the warehouse buildings on the western edge of the map goes to zero in 2013, after the installation of solar panels. There are some evident hotspots on campus where electricity use has remained consistently high, though these two figures display slight decreases in electricity consumption overall. It is important to note that there is some data not included in this map, including Commons and Anna Mann, but that this does not indicate zero energy use.

Lastly, Figure 9 depicts the electricity use of on-campus dorms, academic buildings, and faculty houses. The highest data point, shown in red, is the Educational Technology Center (ETC). This is not surprising given the fact that the building is home to the highest concentration of computers on campus. Most importantly, this figure shows that there is not a linear relationship between the year that a building was built or recently renovated and the amount of electricity it consumes. Instead, the graph demonstrates how the specific function of each building has much more influence on how much electricity it uses. Perhaps unsurprisingly, academic buildings generally consume significantly more electricity than faculty houses and most dormitories.



Reed buildings: Year built

Data sources: Street data and residential building data from RLIS/Metro;
Reed College roads/paths and buildings via openstreetmap; Reed campus building data and energy data (tabular) from Reed College.



Reed buildings: Year built OR year renovated (most recent listed)

Data sources: Street data and residential building data from RLIS/Metro;
Reed College roads/paths and buildings via openstreetmap; Reed campus building data and energy data (tabular) from Reed College.

Figure 6. Campus Buildings By Age. Top panel: buildings colored by year constructed; bottom panel: buildings colored by most recent major renovation.

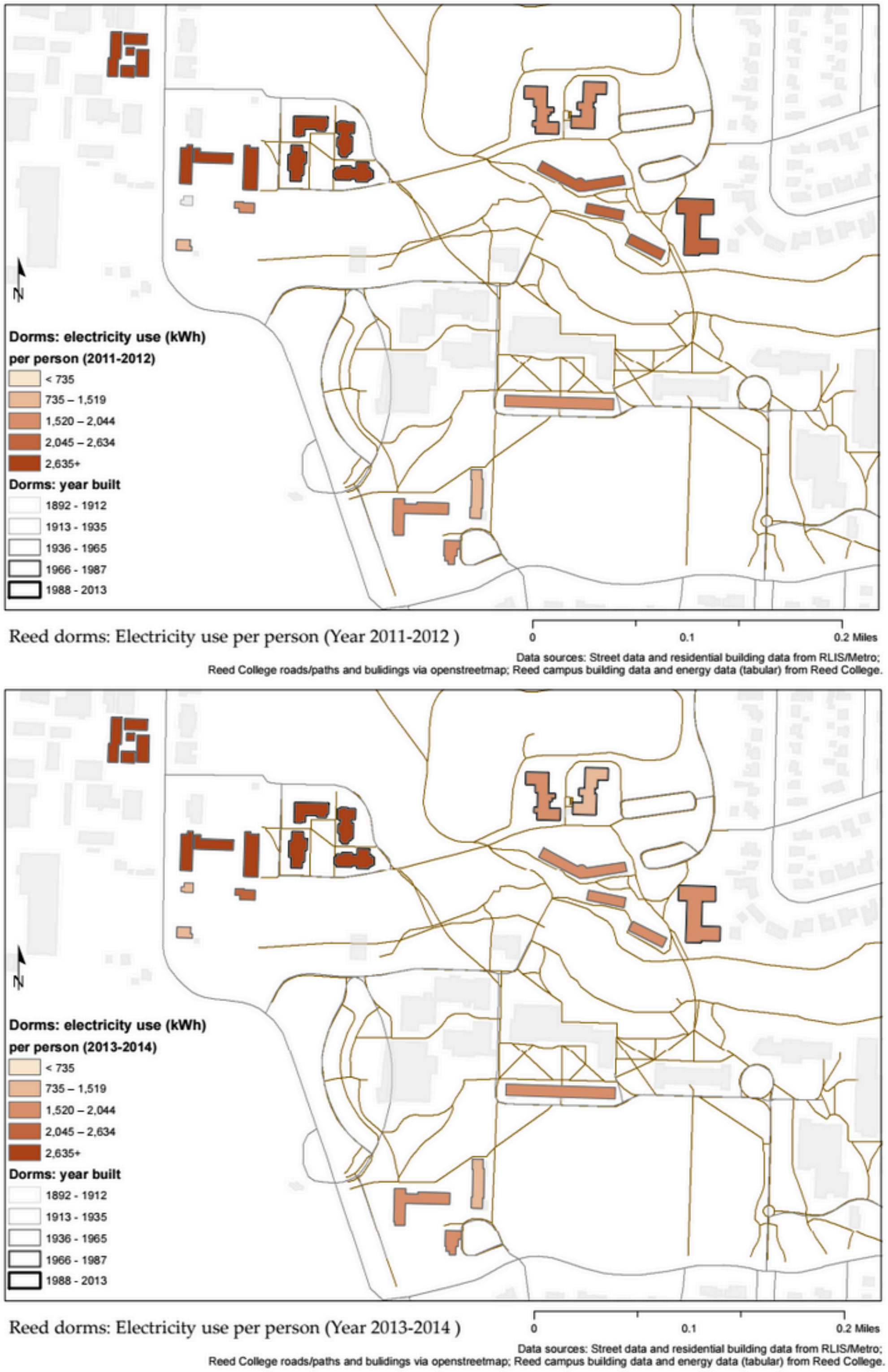


Figure 7. Annual Dorm Electricity Use Divided by Maximum Occupancy. Top panel: 2011-2012; Bottom panel: 2013-2014.

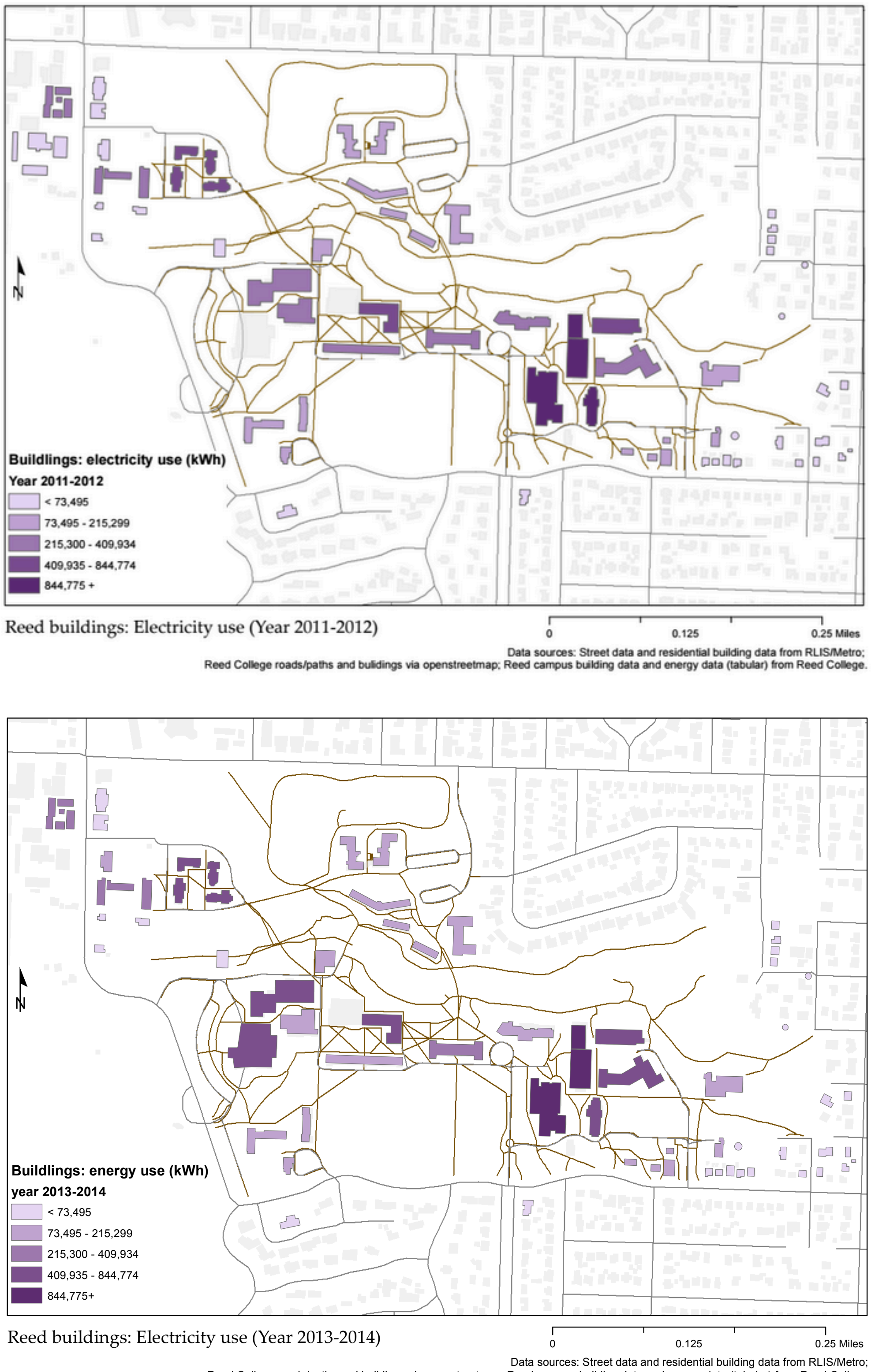


Figure 8. Annual Campus Building Electricity Use. Top panel: 2011-2012; Bottom panel: 2013-2014.

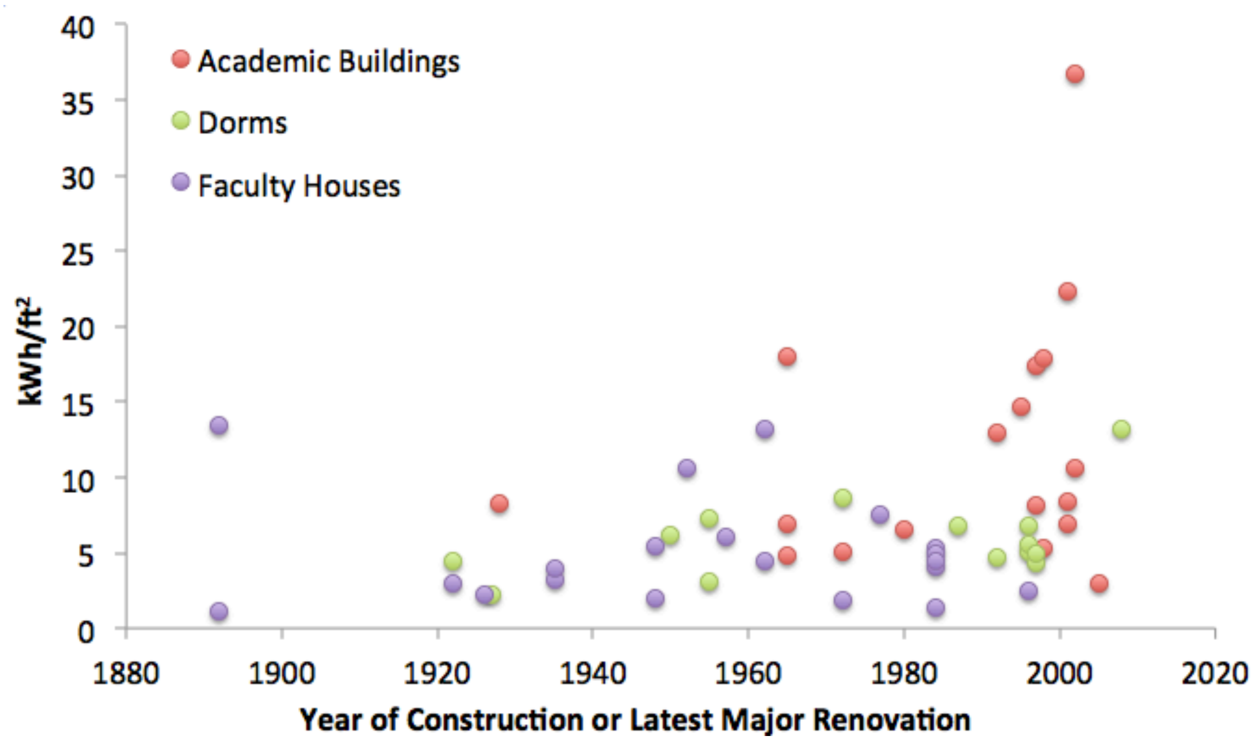


Fig 9. Annual Campus Building Electricity Use Divided by Square Footage

Figure 7 shows that dormitory energy use varies greatly, with the Grove using substantially more electricity than any other dorm. To investigate this in more detail, Figure 10 shows a typical annual cycle in energy use for three dorms, the Grove (newest dorm on campus), Old Dorm Block (ODB, the oldest on campus), and Naito (the newest dorm built prior to the Grove). It is notable that the Grove's winter electricity consumption is substantially more than its comparators, even in January when all three dorms have reduced occupancy for long periods of time.

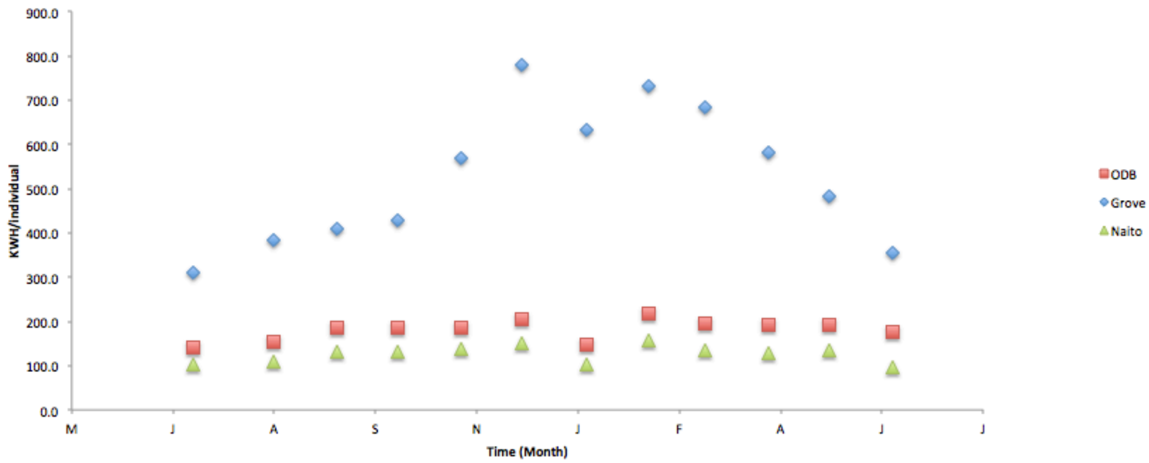


Figure 10. Monthly Average Per Occupant Electricity Use from July 2010-June 2011 for Three Representative Dormitories.

5. Behavior Change

As previously mentioned, energy use on campus is not the responsibility of facilities alone. Individual behavior is aggregated to make the whole; a balanced approach to managing electricity use must target individual actors, as well as institutional actors. Thus we have included a short guide to behavior change campaigns, as compiled through our own research. We recommend in future behavior change campaigns whose goal is to reduce student energy use that the Grove is prioritized as a target, considering its energy use per person and per square foot is unusually dense.

5.1. Identifying Successful Behavior Change Strategies

Behavior change campaigns are an oft-used tool by groups to make an institution "greener". However, crafting a successful behavior change campaign requires specific knowledge of effective behavior modification tactics. As campus environmentalism requires individual as well as institutional change to be holistically successful, methods for constructing a successful behavior change campaign are summarized below. The tactics below have been used by the Environmental Studies Junior Seminar of 2015, as well as past Student Sustainability Coordinators.

Research has consistently shown that education alone is not sufficient for effective, long-lasting behavior change. Even when in combination with rudimentary persuasion, long-term success is unlikely. Other, more nuanced factors of behavior modification are necessary for success over a long period of time.

Both Michael Slater[14] and Doug McKenzie-Mohr[15] in their work on behavior modification place heavy emphasis on specificity in both the planning and the messaging itself: when designing a campaign, stating the target audience, specific goals, intended methods for measurement, and all other relevant details success are key. Also identified by McKenzie-Mohr is an element that we've discussed previously in class: making a behavior important to a person, making that behavior part of their value-set or personality. Doing so well is difficult and involves an emotional and moral appeal, but increases the sticking power of the message.

Brian Cugelman et al.'s research concurs with the focus on goals, and moral messaging. They assert that more effective messaging focuses on, "assisting [participants] in reaching goals, and providing normative pressure." A particularly salient method used in this study was the use of "components aimed at showing users the consequences of their behavior"; for example, the individual electricity-use data our class collected using the HOBO device.[16]

While some studies zoom in on a few factors in changing behavior, some researchers like McKenzie-Mohr have published holistic methodologies for launching behavior-change campaigns. His methods known as "Community Based Social Marketing" or CBSM can be adopted in their entirety; a piecemeal approach is also possible. Both appear to have similar potential for success. For those pursuing the holistic approach, the Community Based Social Marketing sources are the most logical jumping-off point. For those pursuing the piecemeal approach, a short list of quick takeaways synthesized from all of the readings is listed below.

[14] Slater, Michael. 1999.
[15] McKenzie-Mohr, Doug. 1999.
[16] Cugelman, Brian. 2011.

- Negative, or shaming, campaigns either don't work or have limited success.
- Create pilot programs before doing full-scale implementation.
- Repeated reminders, interactions, and/or prompts boost success.
- Education and information dispersion is not sufficient for lasting change.
- Often, incentives work; particularly, financial incentives.
- Identify behaviors to target and change; tackle them specifically.
- Regular evaluation is a key to long-term success; third-party measurement is favored over self-evaluation.
- Coercion does not produce long-term success.
- Use active involvement and participants' views of self as tools.

6. Next Steps

We recommend several next steps, the first of which is energy monitoring, including expansion to collecting data on individual building-level gas use for heating. Data collection and continual monitoring is key to identifying opportunities for improvement, with regard to our energy-related carbon footprint. Such monitoring would better inform any further energy efficiency projects, such as the continuation and expansion of appliance replacement.

The addition of more solar panels to campus buildings is another practical next step. During the summer of 2013, solar panels were added to the roofs on the warehouse buildings with resounding success; the block of buildings on the western edge of campus are now effectively carbon-neutral in their electricity use. The Performing Arts Building is a feasible candidate for solar panels, as its roof is well equipped for them, and it is a high energy use campus building.

If creating green power of our own proves too infrastructure-intensive in the short run, it is possible to achieve clean electricity through our current provider, PGE. It is possible for Reed to opt into Clean Wind, a billing option that adds an extra fee for new wind development or Green Source, which promises to offset all electricity usage with renewable energy. PGE's description of the Green Source mix for 2015 option states, "this product will come from approximately 98 percent new wind, 1 percent new geothermal and 1 percent new solar energy." By choosing Green Source an electric bill of $1,000,000 per year (about what Reed pays) would rise to $1,101,634. Though we recognize that a 10% increase in the College's electricity billing is not insignificant, it puts carbon-neutral electricity sourcing within reach.

We also recommend further individual education, in the form of both behavior change campaigns and an expansion of the educational opportunities surrounding environmental issues. Reviving "The Power Struggle," an inter-dorm competition to reduce energy use for prizes would be an especially effective educational and behavior change tool if implemented during the winter months when electricity use is particularly high. Though past "Power Struggles" have not produced energy-saving effects after the end of the competition, longevity could be better maintained with more long-term incentives. As shown in Figure 10, targeting dorms during the winter months, especially the Grove, would likely produce the largest effects.

Switching to clean power would make a powerful institutional statement; projects to curb individual use spreads responsibility amongst the community. We firmly believe that institutional change should be coupled with individual change for lasting effects.

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8. Appendix: Amaresco Quantum recommendations by building.

Reed Campus Lighting: Replace T-12 magnetic ballast, incandescent or HID fixtures with T-8, electronic ballast, compact fluorescent or LED Estimated energy savings-879,880 kWh annually Guaranteed energy savings- 791,892 kWh annually Increase in gas will not exceed 6,944 Therms annually
Boiler Plant: Installing new boilers Estimated energy savings= 20,013 Therms annually.
Walzec Sports Center: Variable Frequency Drive on gym air handling unit Estimated energy savings = 18,383 kWh and 594 Therms annually Guaranteed energy savings = 16545 kWh and 535 Therms annually
Grey Campus Center: Control upgrade and replacement Estimated energy savings- 101,594 kWh and 15,207 Therms annually Guaranteed energy savings- 94,435 kWh and 13,686 Therms annually
Vollum College Center: Update of air handling units Energy Savings Estimated energy savings- 37,496 kWh and 1,725 Therms annually Guaranteed energy savings- 33,746 kWh and 1,553 Therms annually
Hauser Memorial Library: Controls upgrade and replacement Estimated energy savings- 55,621 kWh and 27,710 Therms annually Guaranteed energy savings- 50,059 kWh and 24, 939 Therms annually
Education Technology Center: Controls upgrade and replacement Estimated energy savings- 31,682 kWh and 8176 Therms annually Guaranteed energy savings- 28,514 kWh and 7,358 Therms annually
Psychology Building: Controls and commissioning Estimated energy savings- 39,527 kWh and 11,082 Therms annually Guaranteed energy savings- 35,574 kWh and 9,974 Therms annually
Scott Laboratory of Chemistry: Controls and commissioning Estimated energy savings- 74,612 kWh and 16,991 Therms annually Guaranteed energy savings- 67,151 kWh and 15292 Therms annually

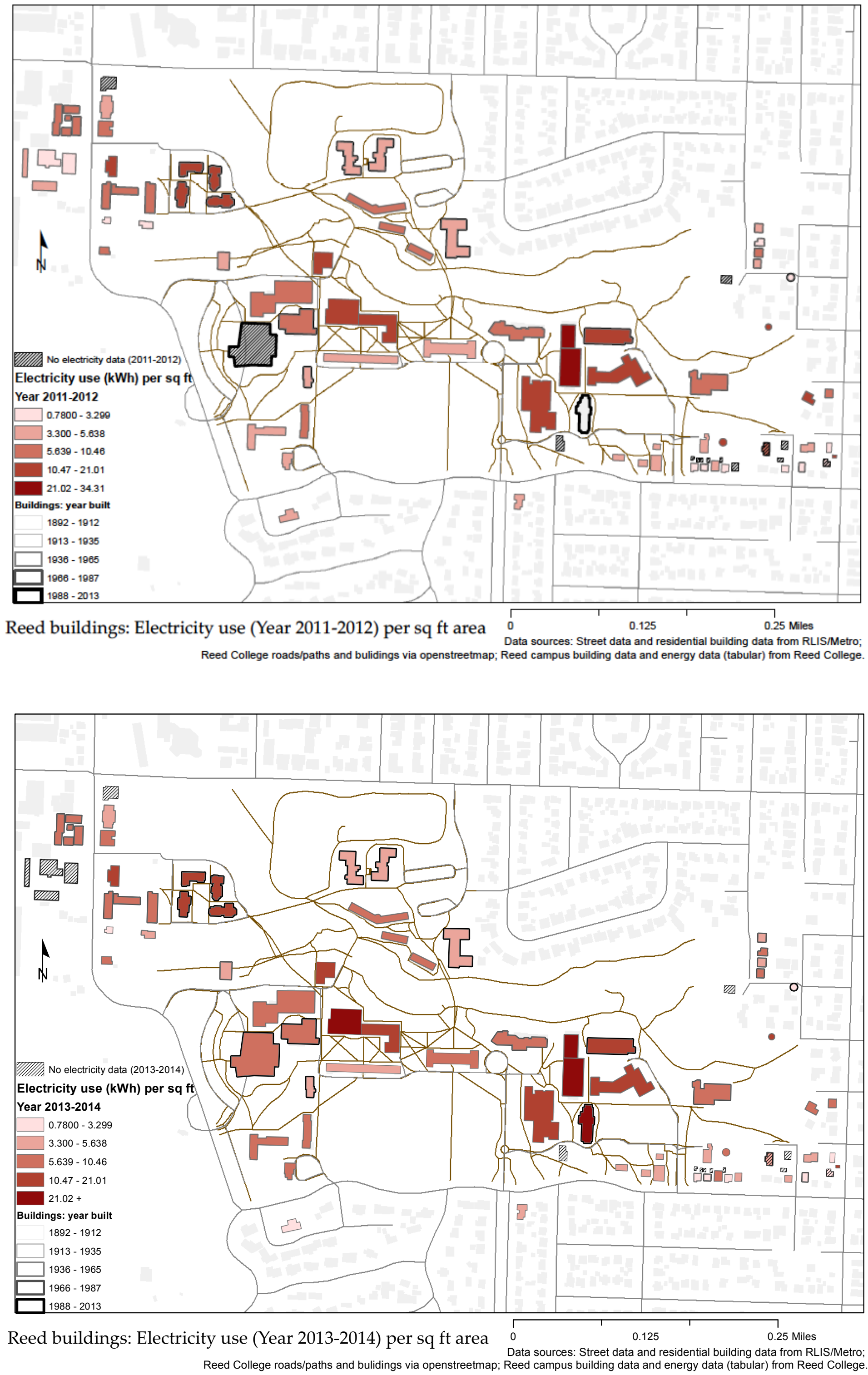

Figure A1. Annual Campus Building Electricity Use Divided by Square Footage. Top panel: 2011-2012; Bottom panel: 2013-2014.

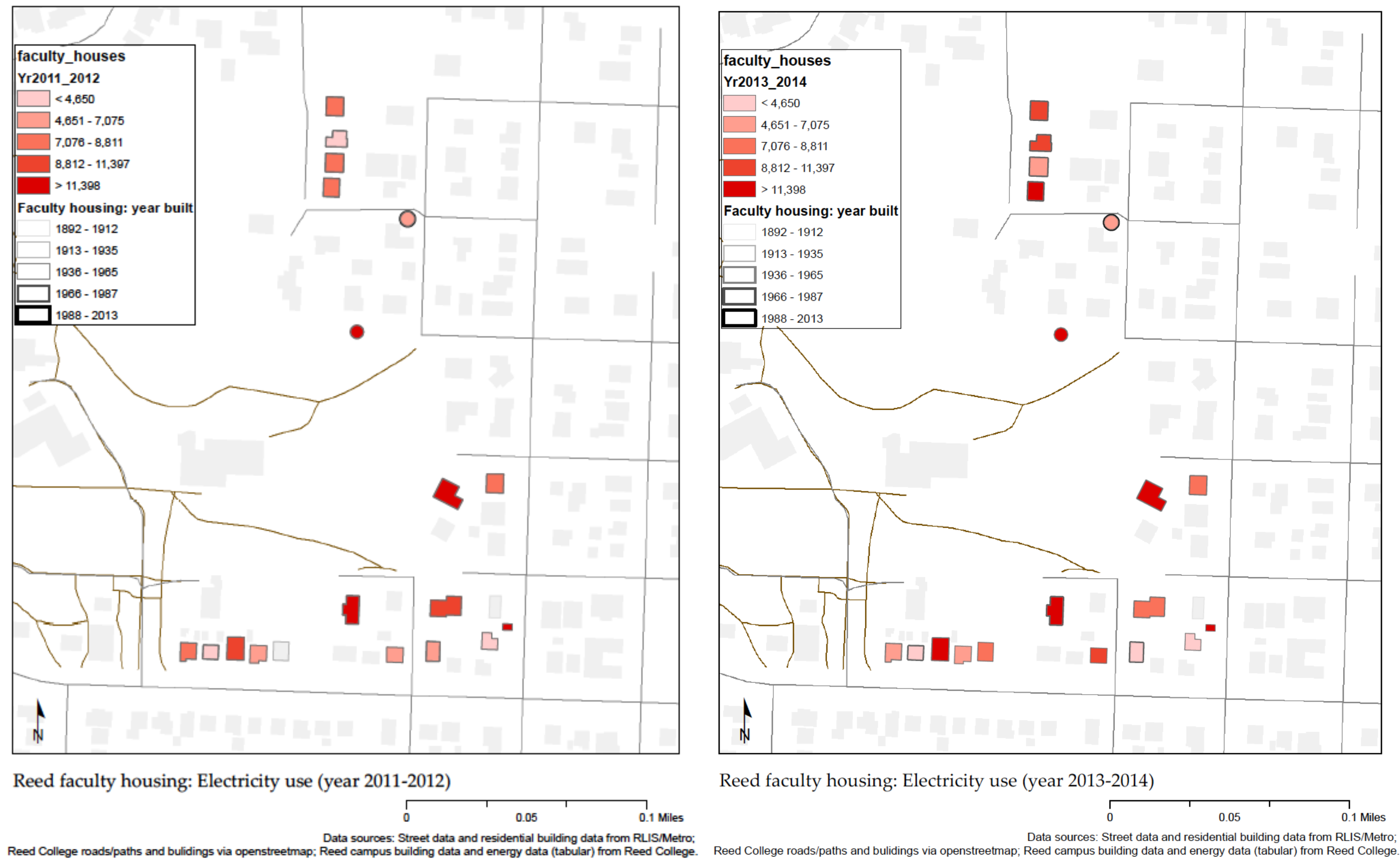

Figure A2. Annual Reed-owned Faculty House Electricity Use. Left panel: 2011-2012; Right panel: 2013-2014. Circular objects indicate approximate locations of houses for which the footprint was unknown.