

ACTION BEYOND THE PLAN:
A Climate Template for Higher Education

by
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A THESIS

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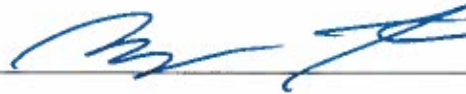
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Institutions of higher learning are meant to propagate forward thinking and innovation through academic research, discourse, and social engagement. As our world strives towards building systems of sustainable energy generation and use, universities and colleges should be leading the way in the promotion and lifestyle of carbon neutrality. Most schools claim to be sustainable without clear metrics to demonstrate and prove success. While certain schools have gone as far as to commit to carbon neutrality by a certain date they have not yet invested in the necessary infrastructure to achieve this. Moreover, the ways in which these schools reach carbon neutrality vary based on financial availability, land availability, and student or faculty enthusiasm. The purpose of this thesis is to analyze why and how specific schools are not meeting “sustainable” standards and how, through a tailored and quantifiable solution, places of higher learning can become places of forward thought and positive role models of sustainability.

Acknowledgements

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Introduction

Sustainability and Climate Change

“Sustainable development...implies meeting the needs of the present without compromising the ability of future generations to meet their own needs.”
- *The World Commission on Environment and Sustainability*

Global climate change is caused by the Greenhouse Effect. The Greenhouse Effect occurs when the atmosphere intercepts short-wave radiation from the sun and, because the atmosphere has a finite temperature, it reradiates the excess temperature. Half of the short-wave radiation from the sun will be radiated down on to the earth's surface. The earth's surface will then reemit long-wave radiation back into the atmosphere as it tries to reach thermal equilibrium. The atmosphere then absorbs 2/3 of the emitted radiation. Due to the burning of fossil fuels, greenhouse gases such as Carbon Dioxide and Methane are released into the atmosphere and cause it to absorb more than it naturally should which causes atmospheric warming. Of all the CO₂ emissions produced from burning fossil fuels, the United States is responsible for emitting 14.4 trillion pounds of carbon dioxide, a 5% increase from 1990 (<http://www.epa.gov/climatechange>).

If the burning of fossil fuels continues on a 'business as usual' trajectory, our planet will face a global temperature rise of 5 to 15 degrees Fahrenheit over the next century (<http://climate.nasa.gov/effects/>). This temperature increase will require significant adaptation strategies in various countries and regions. The best current example is the drastic drought in California. As the push for sustainable development continues to gain momentum, institutions are being rightfully pressured to adapt new methods of conducting business. Places of higher learning are good examples of

institutions that are being asked to examine their current status' as greenhouse gas emitters and what changes can be made fiscally, socially, and academically to reach carbon neutrality.

In this thesis I will give broad-scope suggestions and quantifiable solutions for how colleges and universities can curb CO2 emissions created by on-site electricity use through the use of renewable energy. The suggestions and solutions are attempts at deriving a more specific definition of sustainable development as it pertains to institutions of post-secondary education.

Why Post-Secondary Education?

“Sustainability and its implications should not merely be defined within a political context but should have resonance within academia and remain at the centre of debate, engaging individuals in deeper realms of thought.”

-‘The Sustainability Curriculum’, Cedric Cullingford

Historically, universities are institutions built on the foundations of preserving the rituals of academia and perpetuating and expanding upon existing rhetoric. Because institutions of higher learning are defined as ‘preservationists’ of thought, they are often too entrenched in tradition and ritual to propagate innovative thinking. However, as the stepping stone for young, excitable, and inherently innovative scholars, universities have the unique potential to be leaders in growing movements.

From a statistical standpoint, institutions of higher education represent 21 million students, or 5.7% of the total U.S. population, and spend an estimated 14 billion dollars on on-site energy costs annually (US Department of Education). From *The Green Campus: Meeting the Challenge of Environmental Sustainability*, editor Walter

Simpson explains, “energy reflects the single largest environmental impact of a campus- and the biggest potential payback” (Simpson, Green Campus). On-site initiatives for renewable energy, such as solar, have payback periods of only 3-5 years, while retrofitting an existing building up to LEED standards has a payback period of 8 years (usgbc.org). This means that while upfront costs to universities may initially exceed the current 14 billion dollars annually, within 5 years, institutions would start to see a drastic reduction in their annual expenditures.

Currently, the U.S. total of 4000 institutions of post-secondary education are responsible for emitting over 6% of the country’s greenhouse gas emissions, which only factors in on-site energy use and omits transportation taken to and from campuses. (Hoffman, Greening the Gator, 8). “By demonstrating that campuses can operate effectively while curtailing greenhouse gas emissions, institutions of higher learning can show what is possible and point the way for others” (Hansen, The Green Campus, 27). As large contributors to CO2 emissions and with ample sources for reductions, why are institutions of higher education not doing more to become leaders in sustainability?

One reason may be the previously mentioned pedagogy of preserving certain legacies in exchange for embracing innovation. For example, architecturally, campuses are required to follow strict aesthetic rules rather than allowing new buildings to display advancements in thought, technology, and technique. Ironically, campuses usually shy away from publicly displaying the achievements in art and technology that their buildings contain. Instead, newly erected buildings must adhere to the standards of their older counterparts. At the University of Oregon, for example, Ellis Lawrence was hired as the campus architect in 1909 and erected seven university buildings, all brick-clad.

At the time, brick was cheap and plentiful in Oregon (Teague, *University of Oregon Architecture*). Now, however, despite having other suitable building techniques that could express building characteristics and individuality within the campus, the university mandates that all buildings comply to a standard set over a century ago. The importance placed on historical context and preservation should be re-evaluated in the context of today's needs if a campus wants to pursue sustainable development.

Another reason why institutions of higher learning are not yet leading the way in sustainability is the lack of transparency and regularity across the board for sustainable initiatives. Although outside organizations exist to help propel universities into more rigorous sustainable activity, there is no national standard for colleges and universities to adhere to. Therefore, universities set their own standards for how much involvement and knowledge students, faculty, and outside parties have about campus sustainability. Even within a university, academic and administrative groups can have differentiating views on sustainability that hinders progress. "The institutions available to meet these challenges are demonstrably incapable of long-range planning, dominated by peculiar and special interests, fragmented in authority and responsibility, and designed to allocate abundance, not scarcity" (Hales, *Sustainability in Higher Education*, 2).

Along with broad-scope suggestions and quantifiable solutions for each school's renewable energy goals this thesis will provide a template for those looking to measure the potential for renewable energy generation of an institution. The template, which will outline important steps to take and figures that one should look for, is an attempt to rectify the discontinuity of available information between universities. Ideally, with the continuous efforts of those seeking information and involvement in campus

sustainability affairs, knowledge and activity will become more public. Which will in turn, push institutions of post-secondary education to continue their own efforts and growth of sustainable development.

Greening the Campus by Isha Wilson

The starting point for this research project came from the inconclusive findings of a past thesis project by Isha Wilson, completed in 2011. Wilson studied colleges and universities within the American College and University Presidential Climate Commitment (ACUPCC) dataset of signatories to determine which types of schools, if any, were making progress to reach carbon neutrality. The ACUPCC is a project operated through the Association of the Advancement of Sustainability in Higher Education (AASHE) and may be signed by any institution of post-secondary education willing to commit to carbon neutrality by a certain date. Wilson focused specifically on carbon neutrality reached through reductions of energy use and the production of renewable energy. To maintain continuity and build upon her research, any discussion of carbon neutrality in this document will refer to the carbon impact of electricity use. Wilson hypothesized, “the presence of high goals, a sustainability coordinator, and student initiated green fees will correlate positively with commitment to green energy and building, and that low goals, and the lack of a sustainability coordinator or green fee will correlate negatively with these metrics” (Wilson, *Greening the Campus*, 23).

Although Wilson found some correlation between schools with student green fees and the presence of a sustainability coordinator, her research showed that most ACUPCC signatories, although committed to specific actions by a set date, were not

high performing in sustainable development. Even though Wilson's hypothesis proved inconclusive, her research shed light on the lack of follow-through most colleges and universities have when tackling sustainable projects. As previously mentioned, there is no current system for monitoring the progress and success of sustainable projects on campuses. Even when a school is committed to the ACUPCC, it is the sole responsibility of the university to maintain upkeep of projects and to report their progress.

Of the eighteen schools within Wilson's dataset that proved to be high-scoring, based on her metrics for measuring each school's success, many of them were reaching towards carbon neutrality through the purchase of Renewable Energy Credits (RECs). RECs are tradable commodities that certify that one megawatt of energy was produced by a renewable source, such as wind, solar, hydroelectric, biomass, and geothermal. RECs present a simple and affordable way to support green energy without having to implement new on-site infrastructure. RECs are a necessary means for institutions to reach total carbon neutrality because they help offset whatever greenhouse gas emissions remain after large-scale projects and reductions. However, most schools purchase RECs instead of initiating on-site projects, some can almost claim total carbon neutrality solely through the purchase of Renewable Energy Credits.

The conclusion of Wilson's research showed that most schools were doing the minimum amount of work to maintain their status as "green schools" and those that were high performing, were doing so through the purchase of RECs. Because these institutions willingly signed the ACUPCC only to perform to the lowest possible standards, it begs the question: how much more could these institutions be doing?

Project Description

The project that developed from Wilson's research attempts to answer the questions brought up by her inconclusive findings: could schools be doing more? If so, which steps towards carbon neutrality are most practical? The outcome of this research will generate better defined practical goals for institutions to follow, a process template for other schools to implement on-site projects, and a website that will cumulate the data in to readable statistics and info graphics for the use of students and sustainability coordinators.

The research project can be split in to two categories: research/analyses and data visualization/implementation. The twofold process of research and display is integral to the success of the project. Currently, colleges and universities are not meeting their own standards of sustainability, let alone standards set by outside organizations. One reason for this may be lack of interest or knowledge about existing and future sustainable projects on campuses. To know and understand how schools are currently operating is important and to use that information to set new goals that meet each school's potential is necessary. However, after the research is complete, adapting the data in to a readable form will help place the data, in the minds of the viewers, in to a real world scenario. Edward Tufte, author of *Visual Explanations*, states, "The commonality between science and art is in trying to see profoundly - to develop strategies of seeing and *showing*" (Tufte, *Beautiful Evidence*). If the data collected proves institutions could implement strategies for renewable on-site energy, showing that information in a meaningful manner will help initiate interest in sustainable projects.

The first part of the project, research and analyses, will begin where Isha Wilson's project left off. I will further develop her database by increasing the original set of colleges and universities from 70 to 190 schools. With a larger data set it will be easier to identify trends in energy usage and other measurable metrics. Using this set of ACUPCC committed schools, information about each university's energy use, campus building typology, on-site sustainability projects, REC purchasing, etc., will be gathered to gain a detailed understanding of the current sustainability statuses of each school. Once I have a solid understanding of how each school is currently operating, I can determine what their potential for on-site renewable energy could be. I will specifically be looking at the use of solar energy generation as it has a fast growing market in the United States and there is ample information about purchasing, implementation, and pay-back periods. After determining how schools could use on-site solar energy to offset a percentage of their current electricity use, I will use that information to create a template of my process, representative info graphics and, along with Isha Wilson, a website.

The template will format my process in a way that allows others to apply the same approach of research and analyses that I followed in order to determine possible methods for reducing carbon emissions. The outcome of a research project is important, however, the process of reaching a conclusion is often as valuable than the end result. Throughout the research process, I will be able to determine which pieces of information are critical for understanding how institutions can become more sustainable. I will also know which pieces of information are hard to come by, missing,

or less important. The template will be a constructed manual of my research process curated to include only the necessary steps for measuring potential energy generation.

Along with the template, a website will be built for the use of students, sustainability coordinators, and others that want to know more about sustainability on college campuses and how their schools fit in. The website will display the results of my research graphically and numerically, trends related to sustainability on campuses, the template accompanied by images of my process, and an interactive portion that allows viewers to generate their own 'green campus.' The goal of the website is to show the research results meaningfully in order to generate interest in how universities can become more sustainable.

Methodology

Because this research project is grounded in the research done by Isha Wilson, the primary sources of investigation come from those used by Wilson. With a dataset of 190 colleges and universities from all over the United States, direct contact with each institution was unrealistic and therefore the majority of the figures come from secondary sources. The main resource for deriving the dataset and finding individual figures for each institution was the ACUPCC, with secondary sources of sustainability websites and Google Earth.

Sources of Data

The American College and University Presidential Climate Commitment (ACUPCC) provides an already existing database of post-secondary education

institutions that are committed to carbon neutrality. For this reason, the dataset used in this research comes directly from signatories of the ACUPCC. Specifically, the studied schools are committed to two of the seven “Tangible Actions” that the ACUPCC provides as guidelines for institutions to follow. Of the list:

1. Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent.
2. Adopt an energy-efficient appliance purchasing policy requiring purchase of ENERGY STAR certified products in all areas for which such ratings exist.
3. Establish a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution.
4. Encourage use of and provide access to public transportation for all faculty, staff, students and visitors at our institution.
5. Within one year of signing this document, begin purchasing or producing at least 15% of our institution's electricity consumption from renewable sources.
6. Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution's endowment is invested.
7. Participate in the Waste Minimization component of the national RecycleMania competition, and adopt 3 or more associated measures to reduce waste (<http://acupcc.aashe.org/stats/tangible-actions/>),

the 70 institutions Wilson worked with are committed to Tangible Actions 1 and 5. The purpose behind this was to create and maintain a set of institutions with similar goals and projects. To widen my scope of investigation I selected an additional 120 institutions that adhered to the same two Tangible Actions and all fell under the

carnegie classes of: Baccalaureate Colleges, Masters College or Universities, and Doctorate Universities.

The institutions represent a variety of university types in population, campus size, ownership, etc. Of the 190 institutions of post-secondary education, 85 schools are private and 104 are public. The dataset represents states from every region of the United States: 86 in the Northeast, 31 in the South, 23 in the Midwest, 33 in the West, 15 in the Pacific Northwest, and 1 in the Pacific. The diverse group of schools are all signatories of the ACUPCC and committed to carbon neutrality by a set date.

The majority of the data I used to analyze sustainable aspects of the dataset came from the Climate Action Plans (CAPs) submitted to the ACUPCC by each school. CAPs are mandatory documents required from each committed school that outline their carbon emissions, their committed tangible actions, and their goals and future projects. CAPs are required to be updated every two years and contain the bulk of necessary information for my purposes. When information was missing from Climate Action Plans I relied on the sustainability websites of individual schools and in very rare cases, contacted sustainability coordinators. Limiting the sources of data as much as possible allowed for consistent data collection and minimized the effect of comparing metrics with incorrect data points.

The ACUPCC and university sustainability websites were used to derive figures related to energy use and campus sustainability initiatives. These figures represent the bulk of the background data needed and half of the data needed to measure the solar potential of each institution. The other portion of information needed to measure the

potential for on-site solar energy is the available rooftop square footage of each campus, for which I used Google Earth.

Solar Energy Potential

The primary goal of this research project is to illustrate the possibility for institutions of higher education to reach carbon neutrality through on-site sustainable initiatives. Specifically, I am looking at the on-site generation of solar energy installed on rooftops, however, the same type of process can be applied to other types of sustainable projects. A quantifiable solution means defining how much energy each school has the potential to generate using their existing infrastructure and what the fiscal and institutional implications are.

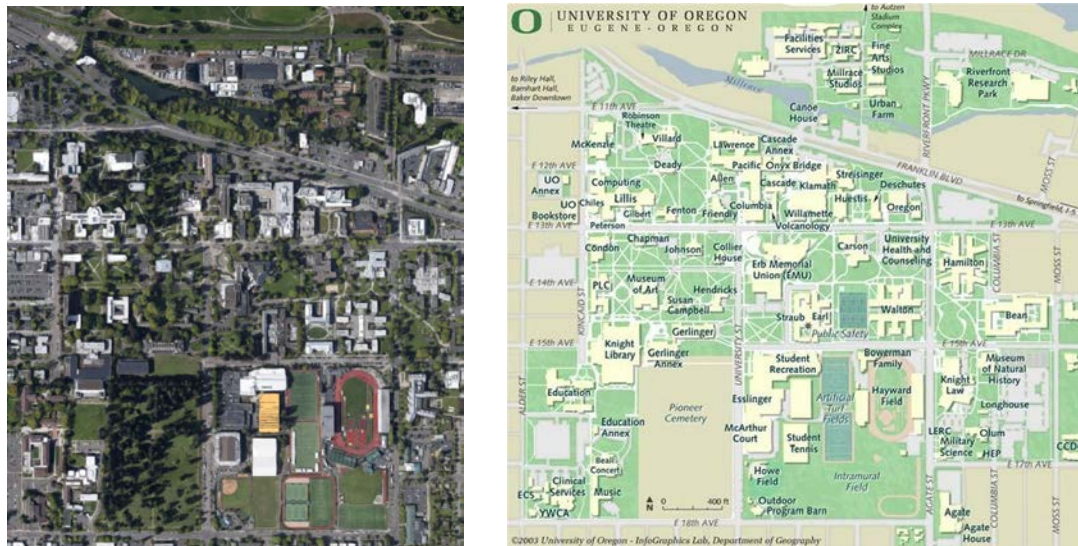
The three types of data important for finding these solutions are: descriptive, logistical, and derived data. Descriptive data was found through the ACUPCC and university websites. Descriptive data is used to gain an understanding of basic characteristics of each institution, for example: ownership, student population, US region, state, and tuition amount. Logistical data is numerical data that is needed to calculate electrical and fiscal figures related to each school's solution. The logistical data was collected in two ways: by reading Climate Actions Plans, and measuring rooftop square footage using Google Earth. The CAPs provided information about: greenhouse gas emissions, percentage of current renewable energy purchasing and use, and total kWh footprint of each campus. Google Earth allowed me to measure the rooftop square footage of each campus. The descriptive data is used in congruence with the logistical data to derive quantifiable solutions for each 190 institutions. The

categorization of the collected data divides the information based on collection methods and implementation process, which inform the creation and use of the template by giving it structure and hierarchy.

Using these three types of data I was able to define solid solutions for each university campus. To quantify each solution I needed to know: the available rooftop square footage, the maximum number of photovoltaic panels to fit on each rooftop, the kWh production of those panels, and the cost per panel and per campus. These numbers provide an idea of what the possible potential for each school is and can be used along with descriptive data to derive cost comparisons and trends.

The first step was to determine the available square footage to install PV panels for each campus. As previously mentioned, I used Google Earth and campus maps to measure the rooftops of each building on each campus. Image 1 shows the comparison between a campus map and a Google Earth image to illustrate my process.

Image 1: Photo Comparison



Using both these images and the measurement tool on Google Earth I was able to select each building and find the rooftop square footage. However, due to HVAC systems, shading, solar orientation, etc., only a percentage of every rooftop can be used for PV panels. The National Renewable Energy Laboratory (NREL) estimates that approximately 50% of rooftops for commercial buildings can be used for solar installations (Melius, Margolis, *Estimating Rooftop Suitability for PV*, 3). Using this number, I calculated the amount of usable rooftop square footage for each campus.

The average dimensions of a PV panel is 38.6” x 58.5”, making it 15.6 sqft. Using this number and the usable rooftop square footage I was able to determine how many panels each campus could support. The next step was to calculate the solar energy generation in kWh each campus could generate with the proposed number of PV panels. To find this figure I needed to know: the insolation (kw/sqmeter) region of each campus and how much energy one panel could produce in its region. To calculate the amount of energy a PV panel can produce in a day I used the formula:

$$kw/sqmt * .1 * 8 = kWh/24hr$$

where kw/sqmt is the determined insolation value of a region, .1 represents 10% efficiency of each panel, and 8 represents eight hours of irradiance per day. The 10% efficiency is the base efficiency of a standard 5 kw PV panel. By multiplying the kWh/24hr by the number of panels I found the total kWh/24hr energy generation of each campus installation. The average energy generation for the dataset is 6,520,547.48 kWh.

With this figure I compared the current energy use and costs of institutions to the energy and costs of the proposed system. The cost of PV panels at the time of these

calculations was approximately five dollars per watt. Since then this number has dipped to approximately two to three dollars per watt (U.S. Department of Energy, Photovoltaic Pricing Trends, v). Using \$5/watt for purchasing costs multiplied by the number of panels I was able to determine the purchasing costs for each institution. The dataset average for purchasing cost is \$32,722.63, which is only \$4000 above the dataset average for the yearly in-state tuition of *one* student. However, it can be assumed that the final number for purchasing costs are slightly higher than in reality due to state rebates for renewable energy. Also, while upfront costs may be high for purchasing and even higher for installation, institutions would need to consider payback periods when determining the financial viability of solar.

Because the main focus of this research is to determine the viability of solar energy on university campuses, comparing current kWh use to the potential amount of solar generated energy was integral. The current kWh use for each institution proved to be one of the most difficult figures to consistently find. Of the 190 institutions considered, the information for 65 institutions was unavailable. However, for the remaining 125 institutions I was able to determine what percentage of their total kWh footprint could be generated using solar energy. On average, 26.3% of an institution's total kWh footprint could be generated using a renewable solar energy.

Other cost comparisons were done to round out the research. Using the U.S. Energy Information Administration's dataset for state by state electricity costs, I was able to approximate how much each institution spends on electricity. On average, the country-wide cost of electricity per kWh was \$0.12 in 2014 and ranges from \$0.08 in Virginia to \$0.37 in Hawaii (<http://www.eia.gov>). Using the total kWh footprint of each

institution and the state I could determine how much each school spends on electricity. I was also able to compare an institution's annual electrical cost to the purchasing price of PV panels. Of the 125 schools, on average the price of purchasing the maximum amount of PV panels possible was 11.29% of an institution's annual electricity costs.

With these figures, each institution within the dataset has a calculated potential solution for solar energy implementation. Conclusions can be drawn from the derived data that can inform other institutions outside of the dataset of their potential for on-site solar installation. The derived data can also begin to answer Wilson's original inquiry of high versus low performing institutions.

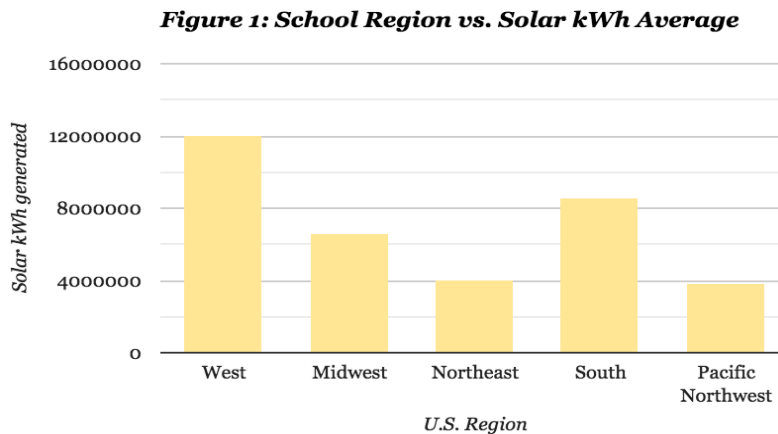
Results and Discussion

The extensive background research completed for each institution made it possible to compare the results from the energy calculations with basic school characteristics. These comparisons are useful in finding trends that help define which types of schools, if any, are more suitable for a large-scale on-site solar investments. Finding trends within the data harkens back to Wilson's original goal of determining which institutions are high performing in sustainable practices. Quantifying each institution's ability to support on-site renewable energy infrastructure does not analyze schools based on performance, however, it brings to light which schools have the potential to be high performing.

Data Trends

To determine which schools have a greater potential for solar energy generation I looked at school region, student population, ownership, and campus building amount. While there are many factors that contribute to an institution's ability to implement solar, these four metrics for analyses represent the broad range of variables that an institution would have to consider: resource availability, supported population, funding, and infrastructure support, in respective order to my metrics.

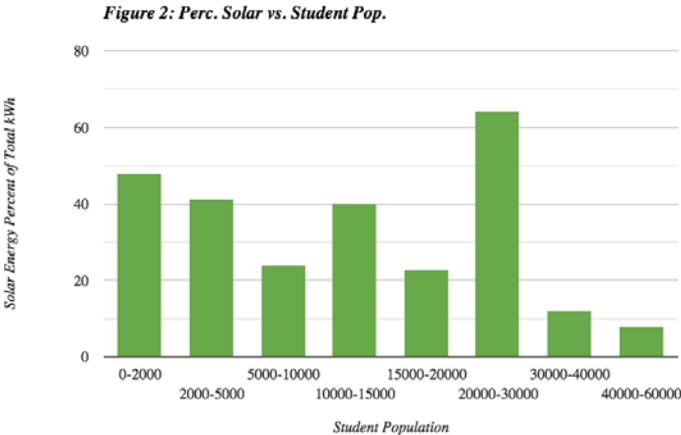
The school region: West, Midwest, Northeast, South, and Pacific Northwest, are determined by the basic climactic conditions of the United States. These regions can be further defined and parsed however the five general regions have enough differentiation in solar irradiance to determine energy generation potential. Figure 1 shows the distribution of the derived potential energy calculation throughout the five U.S. regions.



The Western schools, located in California, Arizona, Nevada, Utah, Montana, Idaho, New Mexico, Colorado, and Wyoming, have the highest average of potential solar kWh generated while schools in the Pacific Northwest: Oregon and Washington, have the

lowest potential. The result is not surprising as the average incoming watts/sqmeter for the West is 277.18 while the Pacific Northwest incoming watts/sqmeter is only 197.09.

The data set represents institutions with a wide range of student population sizes. The smallest school, The College of the Atlantic, has 359 enrolled students, while the largest, Arizona State University, has 76,000 students. Figure 2 shows the



relationship between population size and solar energy potential.

As shown, campuses with a population size of 20,000-30,000 students have the greatest potential for mitigating their energy use with solar, at 64.27%. The second size group with the highest potential is institutions with 1-2000 students with 48.15%. As one can assume, the 20,000-30,000 student group is made up of primarily public universities while the 1-2000 student group is primarily private. This led me to question which ownership type, private or public, has a higher average for potential energy mitigation through solar when looking at the entire dataset. Table 1 shows the frequency of private or public institutions within the dataset, the percent of energy mitigated through solar energy, and how much energy could be generated.

Ownership	Frequency	Perc. Mitigated	solar kWh gen.
private	86	93.86	3672132.63
public	104	25.82	8771824.85

Table 1: Ownership Comparison

The table shows that private schools have a higher percentage for potential solar energy generation. Private schools can produce 93.86% of their current kWh footprint using solar while public schools are only at 25.82%.

Because Table 1 represents the entire dataset whereas Figure 2 represents portions of the dataset, individual schools that are exceedingly high performing within Figure 2 will be more prominent. For example, Northeastern University, a private school with 21,000 students, has the potential to generate over 300% of their total kWh footprint. Although the schools within Figure 2's 20,000-30,000 population group represents primarily public schools as the group with highest renewable energy potential, it is in fact a private school within the data group that sets it apart. Table 1 supports this and shows that within the entire dataset private institutions have a higher potential.

Private institutions may be better suited for use of solar because of their campus layout and ideology. The private schools within the dataset are typically small liberal arts institutions whereas the larger public institutions, like the University of Oregon, are research-focused schools. The ideology differences between a liberal arts school and a research school is reflected in energy use. Liberal arts schools focus their curriculums on broad-scope studies of humanities and some sciences while research based schools are often science-heavy and offer programs for graduate and PhD level research. The

facilities needed for a liberal arts college are much less energy intensive compared to research facilities and therefore will have an overall smaller footprint even with a similar campus size.

Campus size, the number of buildings or the land availability, is the last metric I focused on to determine institution types with high sustainability potentials. The data points are categorized in to two groups: landscape campuses and urban campuses. Landscape campuses are located outside of major cities and have easily accessible land for expansion. Urban campuses are located in major cities or, when outside of a city, are fixed without surrounding land for growth. The purpose for this differentiation is derived from resource availability. Campuses with accessible land potentially have more room for sustainable practices, such as, solar or wind farms. When comparing the two campus types I found that landscape campuses had a 62% potential for solar energy mitigation while urban campuses had a 44% potential. The small differentiation in percent potential implies that campus configurations remain fairly consistent despite location. However, schools with large land availability have the opportunity to initiate other sustainable practices, such as small-scale agriculture, solar farms, or ecosystem rehabilitation.

The other aspect of campus size I looked at was the number of buildings on each campus. One can assume that the more buildings a campus has, the greater their energy use would be and therefore those schools would have a smaller percent of potential energy mitigation. However, with more buildings, campuses have more usable rooftop space for PV installations. Figure 3 shows the relationship between the number of buildings on campuses to the average percent of potential energy mitigated.

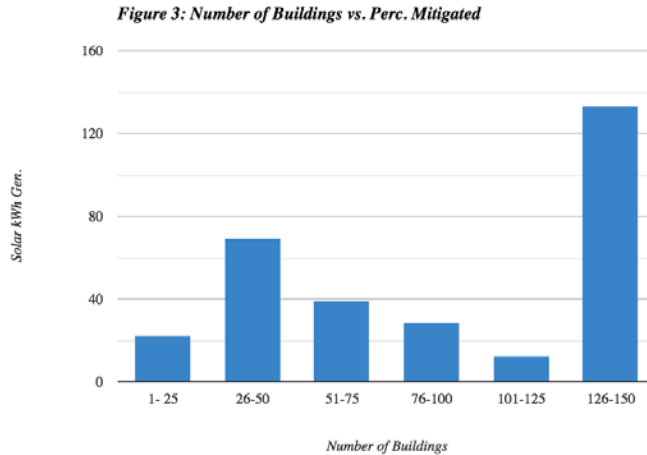


Figure 3 shows campuses with 126-150 buildings as the highest potential gainers for solar energy. However, within the group of schools is an outlier, UC Santa Barbara, which has the possibility to mitigate over 100% of their total kWh footprint. Without UCSB, campuses with 126-150 buildings only have the potential to produce 8% of their current footprint using solar. Assuming most large campuses use enough energy to overshadow their usable rooftop space, campuses with 26-50 buildings have the highest potential at 69.21%. A quarter of the institutions within the 26-50 fall within the 20,000-30,000 student range and exactly half of the schools are private. The graph shows a steady drop-off rate in potential solar kWh generation once campuses reach above 50 buildings. This means the presumed advantage of more buildings and thus more usable rooftop space is not actually an advantage because buildings require more energy than they can physically support with solar.

Data Conclusions

Looking at the four metrics: school region, student population, ownership, and campus building amount, offered insight to which institutions have better possibilities

for generating higher percentages of their current kWh footprint using solar. Although there are certain outliers, for example, University of California Santa Barbara, the consensus within the dataset shows that private institutions can generate larger portions of their energy using solar. Most private institutions have smaller scale campuses and three quarters of the private schools within the dataset have less than 50 buildings. This statistic supports the results of Figure 3: Building Number vs. Solar kWh Potential and the ownership comparison in Table 1. While generally private institutions may have an overall advantage over public institutions, public institutions with 20,000-30,000 students have the best chance of mitigating their energy use with solar. And, of course, when comparing regions in the U.S., any institutions in the Western region has a better chance when compared to other parts to he United States.

As previously mentioned, private institutions have higher percentages of energy mitigation potential for numerous reasons. First, the ideology behind many private, liberal arts, colleges supports an infrastructure that requires less energy. And, secondly, typical campus sizes for private institutions are within the range of 1-50 buildings which proves to be the most sustainable size.

Data Inconsistencies

The effect of any data collection inconsistencies were mitigated by the narrow scope of sources and collection methods. However, inevitably some inconsistencies occurred that could have skewed the outcome of certain figures.

A limitation in the method of quantifying each renewable energy solution was the lack of consideration towards schools with existing percentages of renewable

energy. Many of the schools within the data set have purchased some amount of Renewable Energy Credits (RECs) and are therefore already offsetting some percentage of their total kWh footprint. While incorporating this piece of information into the data results would have been interesting, the outcome without the inclusion is still useful. Institutions that rely solely on RECs could instead finance on-site renewable energy projects along with REC purchases. For education institutions having on-site projects as opposed to only RECs would advertise the possibility of sustainability in a way that unseen RECs are unable to do.

When a figure could not be found within the Climate Actions Plans I relied on the individual sustainability websites of universities. This limitation could only affect the outcome of the data results if the figure was collected differently in comparison to the method used by the ACUPCC or if the figure was out of date. The CAPs are required to be updated every two years, which keeps the information relatively up to date. Sustainability websites are updated at the whim of the university and are not noted when updated. The institutions with missing information in their CAPs often had multiple points collected directly from sustainability websites, which made the collection consistent again.

The research process shed light on which types of information are easily accessible and which types are not. Typically, university sustainability websites are mostly 'green washing' and do not provide definitive facts or figures that describe their efforts. This is unfortunate because prospective students looking to learn about a potential university's current or future sustainability projects are reliant upon sustainability websites. The next step is to culminate the knowledge from the research

process and the results of the data analyses in to a template and website for students that addresses the lack of information and green washing.

Template and Website

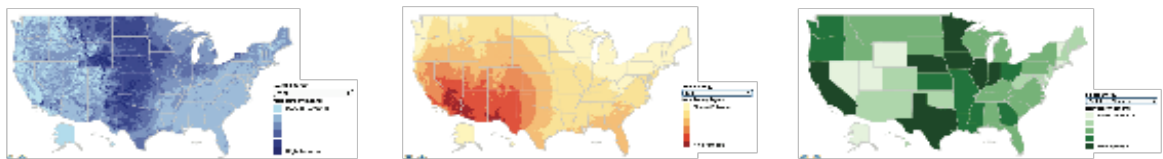
The research process and results are useful on their own but when combined with multi-media tools for showing and advertising the work, the process and results are supported and strengthened. The template and website will be two tools available to students, parents, faculty, and sustainability coordinators, who are interested in learning more about campus sustainability. The creation of the template was informed by the research process and breaks down the method of measuring sustainability potential in to its necessary parts.

The Green Template

The template, which will be accessible on the website, can be used as a guide to determine potential energy generation through renewable sources. The template is divided in to four metrics for research, each derived from my research process. Because the steps are derived from my research, they are geared towards solar energy solutions, however, they are broad enough to be applied to the most suitable renewable source. The four metrics to look at when determining a campus's potential for renewable energy are: resource analyses, infrastructure analyses, current figure analyses, and comparative figure analyses.

Resource analyses means determining what renewable resource is most prevalent in the region and which is most applicable to the campus. For example, a landscape university in Southern California would most likely look at installing PV panels on the adjacent land. Whereas a university in Texas may consider wind energy because of the state's existing infrastructure as the highest producer of wind energy in the country (American Wind Energy Association). There are sources available that display and explain which renewable resources are most suitable for each region. For example, Image 2, taken from the Natural Resources Defense Council website, shows a series of interactive maps of the United States availability of wind, solar, and Biomass, respectively.

Image 2: United States Resource Availability



Infrastructure analyses means knowing what campus infrastructure exists that would support the proposed renewable system. There are two types of infrastructure to consider: physical infrastructure and institutional. The physical infrastructure that affects renewable energy installation would be, for example, whether the proposed campus is a landscape campus or urban campus. Urban campuses would most likely be limited to rooftop installations while landscape campuses could implement both solar or wind farms and with rooftop installations. Also, certain historical buildings, which many university campuses have, are unable to support installations due to the roof configuration and electrical conduit configuration. The institutional infrastructure refers to existing faculty, staff, and student involvement that could initiate and maintain

sustainable projects. Wilson's thesis proved that the presence of a sustainability coordinator, an institutionally hired staff member appointed to oversee sustainable projects, correlated with higher performing institutions. Wilson's thesis also proved that the existence of a 'green fee,' a small optional or mandatory fee from students which finances sustainable projects, correlates with high performing institutions. These small aspects of the institutional infrastructure play a large role in the overall success campus sustainability and should be instated if missing.

Current figure analyses is the process of calculating quantifiable solutions for the determined renewable source. Within this metric there are three secondary metrics to consider: current available infrastructure, current GHG emissions or kWh footprint, and current resource availability. These secondary metrics differ depending on the type of renewable energy being considered and the individual institution. Using solar as an example, the current available infrastructure, if the institution is a landscape campus, would be the usable land square footage. The current GHG emissions of kWh footprint would be the same figure type for every institution and would depend on and variable that effects energy use, such as, the size of the campus and types of buildings. The current resource availability, when looking at solar, would be the insolation value of the region. When looking at wind, the resource availability would depend upon the wind-power density class of the region. Using these three secondary metrics solutions can be derived to determine the maximum potential of renewable energy generation.

Finally, comparative figure analyses uses the quantifiable solutions found using the current figure analyses to look at the implications of instituting on-site renewable energy. The secondary metrics used for this process would be dependent upon the

template user. The secondary metrics I looked at for this research project were primarily financial. I considered the relationship between current expenditures on electricity to the purchasing cost of renewable energy infrastructure. Other cost comparisons could be preformed, for example, the tuition cost compared to the purchasing or installation cost. Whichever type of comparisons are done, the importance of looking at current statistics versus potential statistics is important because it determines the viability of renewable energy through metrics other than energy generation potential.

Action Beyond the Plan Website

The website, a collaboration between Isha Wilson and myself, is a platform to display the above research in a meaningful and understandable format. The website is designed primarily for the use of university students who are looking to learn more about sustainability projects. The design of the website and its content is directed towards those who may be interested in sustainability projects but are unfamiliar with details of the subject. The content of the research will be interactive and visually stimulating to propagate interest in campus sustainability. There are three primary features on the website: data visualization, an interactive 'green campus generator,' and the template and research process which was already discussed.

Author of *The Visual Display of Quantitative Information*, Edward Tufte, defines and describes data visualization as, “consisting of complex ideas communicated with clarity, precision and efficiency. Graphics reveal data. Graphics can be more precise and revealing than conventional statistical computations” (Tufte, *The Visual Display of Quantitative Information*). The content of the data visualization is both

generalizations drawn from the entire data set and graphics describing each institution's quantitative solution. Image 3 shows two examples of interactive data visualizations.



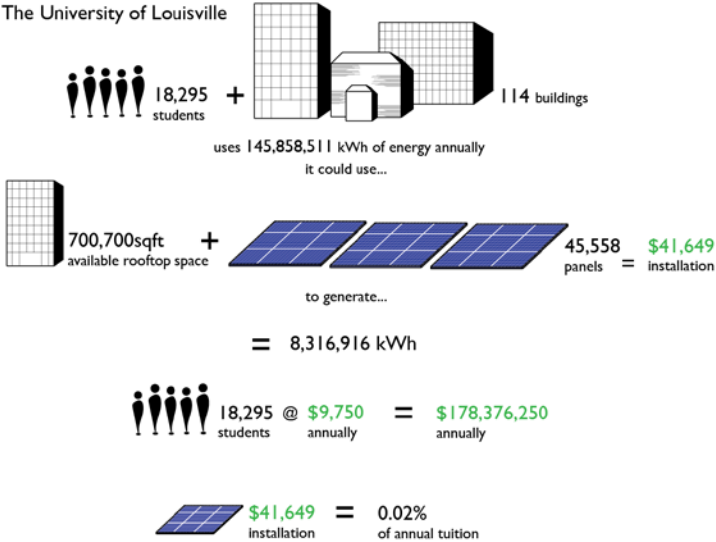
The left graph compares installation costs on the x-axis with annual energy production of solar on the y-axis. The graph represents a second layer of information using color differentiation which represents the solar region of each institution. The U.S. map graphs institutions with green fees as dots and state averages using a color gradient. On both graphs, the data points represent individual institutions and by hovering over the points, the institution name appears. The layers of information and interactive quality of both visualizations makes them more successful than a traditional statistic.

The Green Campus Generator is a tool that allows the user to input certain characteristics of their university in order to generate a sustainable solution. The input characteristics are based on the metrics used for defining institutions with high potential and are: campus building amount, student population, campus type, region, and ownership. By inputting the figures for each metric the website generates three “schools like you” which are institutions from the dataset that have similar characteristics. Along

with the three institutions comes links to their sustainability website, Climate Action Plan, and infographics which describe their qualified sustainable solution. Image 4 is an example of one such infographic for the University of Louisville.

Image 4: School Like You infographic

Students using the Green Campus Generator can use the information provided by the three similar institutions and the Green Template to begin to calculate their own sustainable solutions. The process of generating an outcome tailored to one’s own



campus will create an interactive learning experience that will familiarize the user with the data and encourage them to continue exploring sustainable projects. With links to Climate Action Plans and sustainability websites readily available to the user, the continuation of the learning process will come naturally.

Conclusion

In order to take this research project further, and to supply institutions with more information, approaching the sustainable solutions from a legislative point of view would be helpful. Currently, aside from PV purchasing vs. electricity costs, funding for the dataset institutions was not discussed. There are many ways in which campus sustainable initiatives are funded, through donations, general university funds, grants, etc. The broad scope and lack of clear information for each individual institution made it difficult to analyze in-depth methods for better funding possibilities. However, one funding source that proved very efficient in Wilson's research was the implementation of student green fees.

Green fees are smaller student-supported fees paid annually and go directly towards sustainable projects on campus. Student green fees have been consistently voted in to campuses by the student body, proving that the majority of students are willing to support sustainable projects. With more time, I would have liked to survey students of the dataset institutions without green fees asking if they would be willing to pay \$5-10 annually for sustainable projects. Based on past scenarios, the consensus would be that most students are willing to pay a small fee. For example, in 2005 89% of voting students at Middle Tennessee State University supported an \$8 per semester fee increase to purchase renewable energy. Also in 2005, 91% of voting students at Evergreen State College supported a \$1 per credit fee increase (up to \$20.00 maximum per quarter) to purchase renewable energy and fund the installation of renewable energy and energy conservation technologies on campus (AASHE.org). The overwhelming

percentage of students voting for green fees proves that both those informed and uninformed about sustainable projects recognize the need for adaptation.

In May 2015, the National Association of Scholars released *Sustainability: Higher Education's New Fundamentalism*, a lengthy report which frames the presence of sustainability on campuses as totalitarian and threatening. The presence of sustainability, the NAS argues, “undermines the ideals of liberal arts education, which require mindful attention to many matters that sustainability now deems irrelevant” (NAS, *Sustainability: Higher Education's New Fundamentalism*, 25). The fundamental argument presented against sustainability on university campuses is the stripping of educational freedom that sustainability initiatives impose. The NAS claims the presence of sustainability coordinators, student-run sustainability clubs, and recycling initiatives undermine individual rights by acknowledging and taking a stance on a social and political issue. The fear, as described by the NAS, is that valuable resources, primarily money, are being spent on sustainable projects and curriculum all the while, forcing students to participate in a political movement.

Ironically, liberal arts colleges, the institution that the Nation Association of Scholars is trying to protect, have many characteristics of the highest performing school types within the dataset. Moreover, of the top 15 “Greenest Colleges in the United States,” as voted by the Princeton Review, nine are liberal arts colleges (Huffington Post). The top college, Lewis and Clark College in Portland, Oregon, has reduced its carbon emissions by 30% in the last nine years. The college attributes its success to the “high enrollment and participation by the student population” (<http://www.lclark.edu/about/sustainability>). Of the 54 institutions with green fees listed

on the AASHE website, all are either fees voted in by at least 60% of the student body and/or opt-out programs where unwilling students do not have to participate (<http://www.aashe.org/>). While the argument against the information and conjecture reported by the NAS is too large of a topic to discuss within this thesis, these two examples begin to show the inaccuracies of the NAS argument.

The purpose of this thesis is to show the relative ease with which sustainable projects can begin to be imagined. Rather than reaching carbon neutrality through invisible REC purchases, institutions of higher education should embrace their unique opportunities for interactive education by implementing on-campus projects. While questions of sustainability and climate change are still left to be answered by scientists and environmentalists, the subject should be attainable to everyone. The twofold process of this project of research and display is meant to approach the subject of sustainability both scientifically and humanistically. By inspiring and educating others to continue seeking new and innovative means of sustainability through information sharing this research project becomes a stepping stone in a much wider search for sustainable solutions.

Glossary

AASHE: Association for the Advancement of Sustainability in Higher Education

ACUPCC: American College & University Presidents' Climate Commitment

CAP: Climate Action Plan

CO₂: Carbon Dioxide

GHG: Green House Gases, such as: Carbon Dioxide and Methane

REC: Renewable Energy Certificates – Tradable non-tangible commodities representing only the “renewable” part of the cost of energy production.

USGBC: U.S. Green Building Council<Placeholder: Paste your text here *if you need to copy-paste text from another document – see note in Step 2*>

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