

The Sunnier Side: Solar & Renewable Energy Expansion at Occidental College

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ABSTRACT.

Given both the global threat of climate change and local incentives encouraging the increased adoption of renewable energy production, this research investigates the feasibility of installing additional solar photovoltaic panels at Occidental College in Los Angeles, California. The research investigates opinions regarding the expansion of renewables on campus through a student body survey, analyzes the success and time-to-payback for the current solar panel installation on campus, and examines potential sites for new installations. Potential location analysis focuses specifically on the availability of funding through the Green Revolving Fund, a portion of the college's Endowment dedicated to sustainable projects. Ultimately, the researcher determines that there is a student mandate for the expansion of renewable energy production on campus; that the current installation is reducing utility bills and, therefore, successfully paying for itself; and that various potential locations may qualify for Green Revolving Funding and help to offset carbon emissions, which are expected to increase as the college undertakes large development projects.

INTRODUCTION.

On November 30, 2015, technology venture capitalists Mark Zuckerberg and Bill Gates announced at the COP21 World Climate Change Conference that they and more than 25 other high-profile investors would form the Breakthrough Energy Coalition to stimulate investment in clean energy (Milman 2015). According to *The Guardian*, it is expected that the coalition will “bolster governmental assistance in renewables such as solar to wind energy to \$20 billion” (Milman 2015).

About two months earlier, on October 7, 2015, Governor Brown signed Senate Bill 350, the Clean Energy and Pollution Act, requiring California to generate half of its electricity from renewable sources by 2030. This legislation, one of several similar local and statewide measures, includes renewability and efficiency mandates that rely on utility-providers statewide to take action.

But a clean supply is just one piece of the puzzle. Occidental College is a key player in reducing demand for fossil fuels and spurring the movement toward renewable energy, both as an institution of higher education and as a large commercial property owner in Los Angeles, a

city that contributes substantially to greenhouse gas emissions through its transportation sector. Moreover, it is probable that the college, along with other Los Angeles institutions, will be incentivized both financially and politically to shift to renewables in the near future. That being the case, it is integral that Occidental strategize a path to integrate renewable energy into the campus infrastructure in coming years in order to remain financially and academically competitive in a greening economy.

Occidental College currently does not have a specific goal for generating a greater portion of their energy through renewable sources (i.e. a commitment to achieving X percent renewable energy sourcing by 20X). However, Vice President of Finance and Planning Amos Hammerstein and Sustainability Coordinator Jenny Low are interested in developing a metric to better develop and meet goals for renewable energy projects.

Given the international attention to solar and the more localized efforts outlined in the Literature Review and Background portions of this paper — as well as the fact that Occidental College already has a functioning solar array — the majority of this paper will focus specifically on solar energy projects intended to do just that.

The purpose of this research is to determine whether the implementation of a new array of solar panels at Occidental College would be financially and socially feasible, based on the performance of the solar panels currently installed on Mt. Fiji. More broadly, the research investigates the path for institutions — particularly those with aging infrastructure, such as Occidental — to attain a substantial renewable energy portfolio.

LITERATURE REVIEW

Introduction.

The significance of this research intersects at the existing literature that focuses on the environmental impacts of climate change resulting from the use of fossil fuels, legislation mandating or incentivizing the adoption of renewable energy, campus activism, infrastructural trends on college campuses, and financial considerations unique to colleges and solar projects.

In a recent report compiled by field experts at Family Health International (FHI) 360, the Academy for Educational Development, and the National Council for Workforce Education, Mindy Feldbaum asserts that “new green technologies and discoveries — coupled with new demand and forward-thinking public policies that advance sustainability and encourage public-private investments — are starting to transform the economic landscape as products, services, and jobs are reoriented toward a greener future” (Feldbaum and States 2008, 3). She continues on to state that colleges have a direct role in piloting strategies for mitigating climate change, educating and training a workforce for the fast-growing “green” sector, and integrating environmentalism into curriculum across disciplines (4).

Much of the literature surrounding sustainability in higher education describes the unique position that college campuses have as purveyors of emerging ideas and practices, particularly those ideas which are “in the best interest of the long-term greater good” (Orr, 1994; Corcoran and Wals 2004, 3; Myers 2012, 10).

With these and other motivators in mind, colleges across the world have indeed begun to consider including sustainability as a component of their mission, whether their plans include a shift to local and organic food, a commitment to green buildings, a transition to renewable energy sourcing, or — most commonly — a combination of practices (Myers 2012, 19, 41).

While many schools have these general goals, most lack substantial metrics, policies, and bodies through which to achieve them. This Literature Review will explore the trends and barriers associated with sustainability initiatives on college campuses, paying particular attention to the importance of renewable energy in the context of climate change, recent legislation, and student activism. A focus will be given to solar power, as the research portion of this study examines solar power most closely. However, as much of the solar project literature focuses on highly site-specific case studies, the goal of this literature review will be to discuss the broader framework for solar projects in California colleges, as opposed to specific cases. It will discuss the structures through which these initiatives are created (or, in some cases, excluded) and outline common financial opportunities and barriers that shape the process of solar panel implementation at institutions of higher education.

Environmental Impacts — Climate Change & Renewable Energy.

The wave of legislation and public activism surrounding renewable energy in California is the result of a larger cultural recognition of the adverse impacts that the use of fossil fuel sources (such as oil, coal, and natural gas) have had on earth's climate. Since Charles David Keeling began taking measurements of carbon dioxide (CO₂) in parts per million (ppm) at Mauna Loa in the late 1950s, his self-named "Keeling curve" indicates an abnormally rapid rise in CO₂ ppm from 315ppm in 1958 to a 400ppm milestone in May 2013 (Kunzig 2013). With "safe" levels of atmospheric CO₂ estimated at only 350ppm, the first recorded measurement of 400ppm, and subsequent month-long recordings following the first, are indicators that CO₂ levels may begin to cause deadly natural disasters ("400 ppm," 2015). The abrupt change has

been attributed primarily to an increase in greenhouse gas (GHG) emissions resulting from the human burning of fossil fuels (Kunzig 2013; Heiman and Solomon 2004).

In early late March 2016, CO₂ levels, which are reported at least daily by researchers of the Scripps Institute of Oceanography at UC San Diego, hovered just above 400ppm (“The Keeling Curve” 2015). Ralph Keeling, who currently leads the Scripps team, predicts that after 2015, concentrations of CO₂ would remain above 400ppm permanently (Monroe 2015). As CO₂ levels continue to rise, they threaten rising sea levels and species-eliminating earth temperatures, amongst other expected and unexpected repercussions (Kunzig 2013). Many of these have been long-attested by the Intergovernmental Panel on Climate Change (IPCC), whose findings are intended to inform the decision making of The United Nations Framework Convention on Climate Change (UNFCCC) (Kunzig 2013; Muylaert et al. 2004, 89; IPCC, 2014).

Renewable Alternatives to Fossil Fuels

International discussions consistently prescribe a transcontinental adoption of renewable energy sources as a means of reducing the overall demand for fossil fuels; a 2011 study by the IPCC determined that with appropriate policy implementation, renewable sources could provide eighty percent of worldwide energy demand by 2050 (Muylaert et al 2004, 91; Imhoff 2013, 70). Unlike fossil fuels, many renewable sources — such as solar, wind, hydroelectric, water, and geothermal power — are not finite and do not emit GHGs when producing energy (Imhoff 2013, 70).

In 2014, renewable resources generated 539,809 thousand Megawatthours (Mwh) of energy throughout the U.S. — wind power generated the most, at 181,791 thousand Mwh. Solar power produced 15,874 thousand Mwh (photovoltaic) and 2,447 thousand Mwh (thermal)

(Hankey et al. 2015). Solar and wind power have seen the highest year-to-year increase since 2005, when only 16,535 thousand Mwh were generated from both solar photovoltaic and solar thermal varieties (Hankey et al. 2015).

Renewable Energy in California

In California, solar power is a particularly good option — and not just due to the sunnier climate. Through increased legislation and subsidy, technical efficiency, and high demand, solar panels are quickly becoming a financially and socially feasible means of producing renewable energy (Imhoff 2013, 73; Feldman et al. 2012, 3; Timilsina, Kurdgelashvili, and Narbel 2012, 449). California solar policy has exhibited great leadership and success — as of 2007, the California photovoltaic market was the third largest in the world, following Japan and Germany, and market investment has continued to grow since (Taylor 2008, 2833).

Solar and wind power are both generated based on weather and, therefore, produce different amounts of energy at different times of day, depending on the time of year and location (Nelson and Wisland 2015, 1; Heiman and Solomon 2004, 100). Even temporary weather patterns, including cloud cover and rainfall, can alter the output of panels (Sovacool 2009, 288). Though the California climate enables both of these sources to generate power more consistently than they would in many other geographies, solutions to their inherent variability — such as operating renewable generators below their maximum output, a process called “curtailment” — must be built into the electric grid as the percentage of utility power produced by these popular renewables continues to increase (Nelson and Wisland 2015, 1; Heiman and Solomon 2014, 104). This is feasible, given that according to Benjamin K. Sovacool of the Lee Kuan Yew School of Public Policy, “the capital stock of electric utility infrastructure turns over two to three

times during the course of most people's lifetimes" (2008, 289). If wind and solar powers obtain the legal ability to contribute to the reserves of the power grid operator for the majority of the state's wholesale energy, the California Independent System Operator (ISO), then the somewhat wasteful curtailment process could be reduced by 44 percent (Sovacool 2008, 289; Nelson and Wisland 2015, 2-3).

With appropriate planning and variety in location, solar and wind power can successfully meet demand; in fact, they are already often used as backup security systems for larger power plants (Heiman and Solomon 2014, 104) — trusted to provide supplementary energy when it is most needed. Implementing this system, however, will require the political support required to continue governmental backing of renewable energies.

National and Localized Policy Encouraging the Adoption of Renewables.

Given the substantial attention governments have recently invested in renewable energy legislation, it is important to align Occidental's goals with those of state, local, and national policy (Rauch and Newman 2009).

The legislation reviewed here focuses on California, where the research will take place; however, a wide variety of policies exist across the United States and worldwide. In June 2013, President Barack Obama announced his Climate Action Plan, which consisted of several Executive Actions intended to mitigate carbon pollution in the United States and spearhead the aforementioned international commitments to reducing the adverse impacts of climate change ("The President's Climate Action Plan" 2013, 11). To promote the implementation of renewable energy, the plan includes a mandate that 20 percent of the electricity consumed by the federal government be produced by renewable sources by 2020. It also provides support for a variety of

policies intended to increase investment in renewable energy (“The President’s Climate Action Plan” 2013, 11; Imhoff 2013, 71).

Statewide Policies: Renewable Energy in California

In California, the Clean Energy and Pollution Act, was signed into law at the Griffith Park Observatory in Los Angeles (Megerian and Panzar 2015). The new law requires that “the amount of electricity generated and sold to retail customers per year from eligible renewable energy resources be increased to 50 percent by December 31, 2030” (Clean Energy and Pollution Reduction Act of 2015). In 2006, the California Global Warming Solutions Act (AB 32) passed, requiring the state to reduce emissions to 1990 levels by 2020 in order to combat climate change through the reduced emission of GHGs. According to the California Environmental Protection Agency Air Resources Board, AB 32 is expected to increase energy efficiency and increase renewable energy across the state (“Assembly Bill 32 - California Global Warming Solutions Act” 2016).

This legislation is part of a larger shift in state policy to support investment in and adoption of renewable energy sources, primarily by mandating that utilities providers increase the proportion of power generated from renewable sources (Davis et al. 2014; Imhoff 2013; Muylaert et al. 2004; Rabe 2007).

Renewables Portfolio Standards

Its direct precedent is the Public Utilities Act, which in 2002 established the Renewables Portfolio Standards (RPS) Program and mandated an “increase in the amount of electricity generated per year from eligible renewable energy resources to an amount that equals at least 33

percent of the total electricity sold to retail customers per year by December 31, 2020” (Clean Energy and Pollution Reduction Act of 2015). The 33 percent mandate represents an increase in 2011 from the original 20 percent (Chambers et al. 2011, 338).

As RPS policies, both acts require action on the part of the public utilities and publicly-owned electric utilities, rather than mandating that utility consumers implement a certain percentage of renewable energy sources (Rabe 2007). The most recent legislation includes several revisions to the RPS Program, indicating an ongoing effort to keep the program relevant and up to date (Clean Energy and Pollution Reduction Act of 2015).

In comparing the data on California in the U.S. Renewable Energy Committee report from 2011 to the more recent report published in 2014, it becomes clear that recent policy has become both more common and more specific. While the 2014 report, which summarizes legislation and regulatory actions in each U.S. state during 2013, lists seven actions, the 2011 report for the previous year lists only two (Davis et al 2014; Chambers et al. 2011).

Several examples of these actions indicate improved specificity and innovation in legislative activity. In May 2013, the California Public Utilities Commission approved a power purchase agreement for each of the large investor-owned utilities in the state and expanded their ability to enforce RPS rules on local publicly-owned electricity utilities (Davis et al. 2014, 9). In 2010 — in addition to the aforementioned increase in the required percentage of renewables to 33 percent — the RPS developed a Renewable Auction Mechanism (RAM) through which major regulated utilities can procure smaller RPS-eligible generation projects (Davis et al. 2014). The intent of RAM was to incentivize owners of small generators (up to 20MW) to connect their power to the local distribution grid, with the intent of increasing the proportion of renewable

energy provided by Southern California Edison (which serves Los Angeles), Pacific Gas and Electric, and San Diego Gas and Electric (Anaya and Pollitt 2014).

Consumer-Side Rebate & Incentive Programs

Transitions in state policy to support renewable energy investment are not limited to utility mandates, however. Incentive programs, often run by local utility providers, are available to property owners seeking to expand their renewable power production. Many new policies are solar-specific, such as the October 2013 Equitable Access to Solar Energy Bill (AB 217), through which \$108 million collected for the California Star Initiative was formally approved to incentivize the installation of solar energy at low-income housing. Another, the Senate Bill 43 “Solar Gardens” pilot program, was established to allow customers to purchase power from renewable facilities (Davis et al. 2014). The California Solar Initiative has been a popular means of funding for in-state solar projects (Feldman et al. 2012, v-4). LADWP has also broadened their rebate and incentive opportunities, developing the Solar Incentive Program and Feed-in Tarriff (FiT) Programs discussed in the Background section of this paper.

As both local and national legislation grow more stringent in their mandates for renewables, it will become more important for utilities (and utility consumers, to whom costs will be passed on) to invest in alternative energy sources. Luckily, the resources to do so at institutions of higher education are becoming increasingly available, including student and administrator support, national benchmarking systems, and financing tools.

Campus Activism.

In universities across the U.S., students are leading movements to initiate and expand sustainability objectives on campus (Lipka 2006). Of 16 institutions determined to be “comparison schools” for Occidental, all have sustainability committees or task forces, 13 have full-time sustainability managers, 10 have sustainability offices, and 7 have paid positions for sustainability-focused student workers (Singer-Berk and Bender 2013). According to Himmelstein, these colleges were identified about 5 years ago using 16 criteria, including their comparability in financial figures, student yield and admit rates, diversity indexes, and locations.

Student Activism

Inter-campus coalition building is a common method for students to share ideas and build a larger support network (Lipka 2006). Examples of student-oriented organizing include groups such as the Campus Climate Challenge and U.S. Green Building Council Center for Green Schools Center, amongst a plethora of others (Feldbaum and States 25-26, 30-33). However, formal commitments to many of these programs require at least the signature support of one administrator, reaffirming the necessity of institutional support for many student activists (Humblet, Owens, and Roy 2010, 17-18). Three quarters (12/16) of Occidental’s self-identified comparison schools participate in energy and water saving challenges that are facilitated by committees, offices, and/or paid employees (Singer-Berk and Bender 2013).

Additionally, many student activists have focused on divesting their college’s endowments from fossil fuels. Nearly 500 institutions, including colleges, have active campaigns for divestment; according to Go Fossil Free, an international network for campaigners, 11 Los

Angeles-area colleges and universities have formal active campaigns to divest from fossil fuels (Ritchie and Dowlatabadi 2015; “Nearby Petitions | Fossil Free” 2015).

That same push exists at Occidental, where a variety of student groups have been established to drive sustainability initiatives — whether formally, such as in the case of the ASOC Renewable Energy and Sustainability Fund, or informally, such as through student clubs or the Urban and Environmental Policy and Politics courses. Recognizing the social movement in support of sustainability, the college has established the Green Revolving Fund, created a permanent Sustainability Coordinator position, and even identified the 2015 - 2016 school year theme as “Sustainability” (Tranquada 2014; “Sustainability” 2015). A further discussion of the environmental programs currently active at Occidental can be found in the Background portion of this paper.

Increased Demand for Renewables: Colleges to Lead the Way

For many students, attending an environmentally-conscious institution is incredibly important and, for the majority of students, the presence of these goals can be a factor in prospective students’ decision-making: a 2015 Princeton Review survey found that 61 percent of students said that a school’s “commitment to environmental issues ... would contribute to [their] decision to apply to or attend a school” (Attaran and Celik 2015; “The Princeton Review 2015 College Hopes & Worries Survey Report”). Research has also shown that students who feel a responsibility to the environment are more likely to financially contribute to green infrastructure at their universities (Attaran and Celik 2015).

This is indicative of a larger demand for renewable energy in replacement of fossil fuels. A Gallup poll conducted in 2013 found that two thirds of Americans agreed that the U.S. should

place “More Emphasis” on the domestic production of solar power (76 percent), wind power (71 percent), and natural gas (65 percent) (Jacobe 2013). In contrast, less than half (46 percent) of Americans indicated that they believed the U.S. should put more emphasis on production from oil, and only 31 percent of Americans supported further domestic attention to production from coal (Jacobe 2013).

Involving students in the process of implementing, maintaining, and benchmarking sustainable infrastructure can also be a valuable way to prepare students for future careers. In a growing renewable energy economy, wherein it is projected that by 2030 one in four jobs will be in the renewable energy and energy efficiency sectors, colleges have a huge opportunity to adequately train the future workforce (Feldbaum and States 2008, 13; Rauch and Newman 2009, 394). At institutions of higher education and schools in general, renewable technology can be used as an educational tool for students to practice science, technology, engineering, and mathematics (STEM) subjects (The Solar Foundation 2014, 8; Myers 2012).

By implementing sustainability into curriculum and including students in the process of identifying sustainability initiatives, colleges can help prepare students for career opportunities in the green sector. Furthermore, widespread support for sustainability initiatives from both admitted and prospective students may be interpreted as a mandate for college administrators to take action.

There is an emerging intersection of students and climate action, often resulting in a call-to-action for universities. Students, who learn about climate change and sustainability in their classes, see a disconnect between the college’s curriculum — or, in the case of Occidental college, the annual theme — and the institutional practices. One way for colleges to demonstrate

a commitment to sustainability is by investing in renewable energy through the installation of solar panels and other renewable sources on campus.

Creating Infrastructure for Implementation: Best Practices, Barriers, and Trends.

There are currently a variety of methods for institutions of higher education to formally and informally make commitments to reducing their environmental footprint. Though some larger organizations, such as the Association for the Advancement of Sustainability in Higher Education (AASHE) and Second Nature, exist to provide support for advocates of sustainability on college campuses, many institutions lack a formalized body that helps these individuals effectively plan and implement their goals (Myers 2012, 1).

Common Institutional Barriers and Potential Solutions

The responsibility of creating a process through which sustainability initiatives are incorporated on college campuses, therefore, generally falls solely on students, staff, faculty, and administrators who are environmental advocates (Myers 2012). Little theory exists to examine the relationship between sustainability and organizational initiatives on college campuses; however, research indicates that in higher education there are often “long standing bureaucratic hierarchies and silos that act as barriers to initiatives across the institution” (Myers 2012, 29). The fact that colleges are organized in this way tends to favor the status quo — despite their positionality as an incubator for new ideas, Bradley F. Smith notes that institutions of higher education “seldom [reward] enthusiasm, relevance, or change” (Smith 2000, 84). This presents a greater challenge for student activists, who generally must garner the support of administrators in order to achieve their goals.

In his dissertation entitled “Sustainability in Higher Education: Best Practices, Trends and Obstacles Impacting Champions of Sustainability on College Campuses,” William Myers examines trends, best practices, and barriers in five different categories — leadership and administration, operating practices, curriculum, and community outreach and student involvement — in order to determine whether a system of formal standards and support would increase the success of sustainability initiatives on college campuses and help dedicated individuals more easily overcome otherwise limiting power dynamics (Myers 2012).

Respondents consistently identified several factors as most supportive of sustainability on campus, including active participation from the campus community (stressing the importance of support from key administrators), the incorporation of sustainability into the college mission and strategic plan; targeted school policies, the inclusion of sustainability across curriculums, an evaluation system that recognizes activists’ efforts, personnel resources dedicated to initiatives; and an active community outreach program (Myers 2012, 139).

Similarly, Yale University’s GHG reduction plan, which prescribes the development of a vision statement, the selection of quantifiable goals, leadership endorsement, implementation, and an overall “institutional evolution” to sustainability. The Yale plan is expected to increase their long-term commitment to sustainability, as well as community involvement (Rauch and Newman 2009, 391 -392).

Indeed, these findings are consistent with barriers and suggested solutions identified by many other researchers working at schools, the most common of which appeared to be administrator support and financial feasibility (Myers 2012, 22; Pittman 2004, 205). Often, the two are inherently tied together, as investment in renewable energy projects is assessed to be high-risk. This is partially due to the fact that many individuals responsible for financial

investments — such as those administrators and Trustees with power over endowments — have little to no experience with renewable energy investment (Byrne et al. 2010, 51).

Aging Infrastructure as a Barrier — And an Opportunity

Another institutional challenge is the aging infrastructure of many college campuses, such as Occidental. A large body of research indicates that a main motivator for commercial property owners retrofitting their buildings is the need to replace old equipment (ex. Jakob et al. 2015). This is also relevant for colleges and universities — in a recent study surveying 150 facilities leaders at US colleges and universities, 59 percent of respondents indicated the average building on campus was over 15 years old; 38 percent of campuses had buildings 20 years or older (Schaffhauser 2015).

When institutions do replace aging infrastructure or redevelop older areas of campus, even with efficient design, it can increase their overall energy usage. However, when these projects or other on-campus projects are designed to produce energy, new development does not necessarily result in increased demand for utilities. In this way, energy efficiency and energy generating projects can act as a carbon offset for energy-intensive development projects. A carbon offset is defined as “a program in which a company, country, etc. reduces or offsets its carbon emissions through the funding of activities and projects that improve the environment” (“Carbon offsetting” 2016) — for energy-intensive development projects.

Indeed, colleges and universities have adopted this reasoning; in 2013, the Southern Oregon University (SOU) purchased a 56kW solar photovoltaic system as part of a campus-wide effort to become carbon neutral by 2050 (“College Students Lead Carbon Neutrality Effort with Massive Solar Installation” 2013). As of 2014, 679 colleges and university presidents have

signed the American College and University Presidents' Climate Commitment (ACUPCC) with the goal of becoming carbon neutral institutions (Sirianni and O'hara 2014 and "Second Nature 2014 Annual Report" 2016). The ACUPCC requires signatories to reduce emissions through a standard set of Tangible Actions (TAs), several of which directly reduce carbon by offsetting emissions related to travel and the majority of which relate to reduced emissions through reduced energy consumption.

As institutions of education, many colleges must account for infrastructural, economic *and* human development in their decision-making processes (Corcoran and Wals 2004, 3). Ideally, given that many universities tend have the pre-qualifiers of widespread student support and the presence of several enthusiastic faculty, the presence of sustainability initiatives or goals would increasingly lead to the implementation of programs.

Financial Investment & Savings for Colleges.

However, decisions regarding the implementation of environmentally conscious practices are often instead made with financial security at their core (Pittman 2004, 206; Myers 19). Even administrators who may be more generally supportive of campus greening are more likely to initially reject projects that require the investment of endowment funds (Lipka 2006). Investment here refers to the use of endowment funds to finance renewable energy projects on campus, rather than portfolio investment in solar companies, for example.

As is the case with fossil fuel divestment, sustainable options for endowment investment can yield positive results, both financially and politically (Longstreth 2014). The Sustainable Endowments Institute was founded in 2005 to "lobby for openness and social responsible investing" (Lipka 2006); a recent report developed by the Institute considered the potentially

indefinite investment horizon that is somewhat unique to college endowments — due to the period over which returns will and can be expected, colleges have an amplified opportunity to invest in sustainable initiatives, such as renewable energy projects, which will continue to provide growing environmental and financial benefits (Karp, Orlowski, and Silverstein 2014, 7). Solar panels are subject to accrued savings (or return on investment) over time as they help to manage utility bills, and systems are particularly useful in reducing demand for energy at peak hours, when prices are highest (Byrne et al 2010, 23-33). For Occidental, the low peak season is from October to May, while high peak runs from June to September (Renehan 2015, 5).

The cost savings generated from solar power generation can be passed on to other sections of the institution's budget, such as educational programs or additional staff, or it can be used to pay back the loaner(s) or endowment, as it is at Occidental (The Solar Foundation 2014, 8). In the case that a project does not meet requirements or is not approved for endowment-based funding, other financing options include third-party ownership, loans with debt financing, and bonds or tax-exempt lease purchases, depending on the nature of the institution (The Solar Foundation 2014, 8).

The main methods by which colleges and other properties determine the feasibility of solar projects is by examining the return on investment (ROI) and payback period. ROI is a means of measuring the monetary gains received from an investment over a certain period. Payback time refers to the time (usually expressed in years) it takes to “recover the total energy investment made in a PV [photovoltaic] system” (Keoleian and Lewis 1997, 293-296). There are a variety of methods for calculating return on investment and payback periods, different methods will yield different results in an economic analysis.

A financial analysis is intended to predict the ultimate spending and savings associated with a project or portfolio of projects. A simple payback model includes the initial capital cost of the project and compares that to annual energy cost savings (Deru et al. 2011, 73). While a simple payback analysis will show whether (and when) the savings accumulated annually will be equal to the cost of directly financing a project, it will not account for any interest amassed in situations where money has been borrowed (Martinaitis et al. 2004). However, simple payback models are more easily constructed for more straightforward projects and are often applied when projects have short payback periods (Deru et al. 2011, 72).

While the financing required to cover the up-front costs of renewable-energy production is often identified as the main barrier for institutions of higher education, other common barriers include the added cost of infrastructural changes, such as connecting transmission lines to and from generators to meters (Heiman and Solomon 2004, 111). However, just as on-going operations and maintenance costs can be offset by public incentives and savings accrued over time, these are often one-time costs, some of which qualify for reimbursement through rebates (“Solar Incentive Program” 2015).

The Changing Costs of Fossil Fuels and Renewable Energy.

Saving money while reducing reliance on energy provided by the grid is becoming more important as the cost of fossil fuels continues to rise across the country. While in 2005 the average cost of coal was \$1.54 per million British Thermal Units (MMBtu) and the average cost of petroleum liquids was \$7.59 per MMBtu, in 2014 the average cost of coal was \$2.37 per MMBtu and the average cost of petroleum liquids was \$19.88 per MMBtu, reflecting a steady year-to-year increase in the cost of fossil fuels (Hankey et al. 2015). These costs are passed on to

consumers through utility providers who, as discussed, are also under pressure to reduce the sales proportion of fossil fuels in their energy portfolios.

Simultaneously, the price of renewable energy — particularly solar — is expected to continue declining as a result of increased technical improvement, demand, and legislation (Imhoff 2013, 73; Feldman et al. 2012, 3; Timilsina Kurdgelashvili, and Narbel 2012, 449). Between 1994 and 2004, the price of solar-generated energy declined more than tenfold as a result of improved panel design (Heiman and Solomon 2004, 103). Since then, the cost of installment has also dropped substantially — between 1998 and 2011, the price of installing solar photovoltaic systems declined between 5 and 7 percent per year, on average; just between 2010 and 2011, prices declined by 11-14 percent, dependent on size (Feldman et al. 2012, v-3). Again, between 2010 and the second quarter of 2014, the national average installed cost of solar photovoltaic systems have fell an additional 50 percent, according to the Solar Foundation (2014, 8). While much of the decline in price results from increased technical capability and photovoltaic module cost reductions, it also results largely from government and utilities incentives and programs. For example, the U.S. Department of Energy's 2010 SunShot Initiative reduced the cost of photovoltaic solar power 75 percent by 2020.

A 2012 study conducted by the US. Department of Energy's National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory analyzed data from previous years to catalog declining solar costs and predict future installation costs. The researchers divided solar photovoltaic systems into those 10kW and below, 10-100 kW, and over 100 kW (Feldman et al. 2012, 11-12). Separating panels by size, which often resulted in a separation by zoning sector (residential, utility, or commercial), enabled researchers to more accurately measure trends in cost. Their findings indicate that larger systems — both within each size

bracket and overall — tended to be cheaper, more efficiently installed, and more quickly amortized, regardless of zoning sector (Feldman et al. 2012, 11-12).

The research also separated the cost of solar into the price of modules (generally a 6x10 package of solar cells), inverter (used to change direct current [DC] to alternating current [AC]), and balance of system (“BOS,” the total cost of materials, benchmarking systems, labor, permitting, land acquisition, site preparation, supply chain cost, installer overhead, profit, and sales tax) (Feldman et al. 2012, 10). Much of the predicted decline in future cost will likely be derived from further reduction in the price of module, which is occurring rapidly; for example, module costs decreased 73 percent for commercial rooftop units and 80 percent for utility ground-mounted systems from the fourth quarter of 2010 to the fourth quarter of 2011, and 66 percent of total cost reduction for surveyed residential buildings was attributed to reduced module cost (Feldman et al. 2012, 10). Improved module technology has traditionally lowered the costs associated with BOS, further reducing the overall price of installment (Feldman et al. 2012, 11). Additionally, projections made over the last decade have generally overestimated the future cost of solar. For example, from 2008 to 2011, researchers including Citigroup, Deutsche Bank, Barclays, and Goldman Sachs regularly estimated that solar installation costs would be more expensive than they were in actuality (Feldman et al. 2013, 16-17).

Another advantage of the increased legislative attention to renewable energy is the way those laws have manifested themselves in a series of public investments, rebates, and other incentives that have made renewable energy sources financially attractive to consumers.

Conclusion.

If costs can be mitigated or rationalized, there is a large potential for schools to generate their own power renewably. Though there is little literature synthesizing the experiences of colleges across a range of sizes and locations, case studies consistently indicated a lack of financial feasibility, administrator support, and systematic support as the most common barriers. Understandably, the components most frequently understood to be necessary for effective sustainability initiatives and a commitment to renewables were adequate funding opportunities, support from the campus community, and the presence of school policies and/or personnel formally dedicated to sustainability.

As student interest in the environment continues to grow, reflecting the greater shift in economies and attitudes, opportunities also exist for panels to be incorporated into curriculum. Though some students and professors currently use the solar photovoltaic panels installed on Occidental's campus in 2013, there is a great opportunity for increased academic utilization. There is also a huge potential for Occidental to take advantage of their utility-provider, the Los Angeles Department of Water and Power (LADWP), rebates and their existing financing systems to install more renewable energy campus, whether through another set of panels or any other projects. Reduced dependence on the utility grid, which obtains 33% of its production from coal ("Facts and Figures," 2012), has environmental, energy security, and savings benefits. Given the legislative support and increased affordability of solar panels, many schools have installed solar photovoltaic systems in an effort to reduce their GHG emissions, display institutional commitments to sustainability, and reduce their utility bills.

BACKGROUND.***Solar Power in Los Angeles.***

As one of several national leaders in the implementation of renewables, LADWP offers a variety of rebates incentive programs that have further encouraged the more widespread adoption of renewable energy sources (Heiman and Solomon 2014, 107; “Solar Incentive Program” 2015). As a public utility that has no formal stakeholders to please, LADWP demonstrates well many of the advantages of public power in the creation of consumer demand. Instead, consumers who choose *not* to opt out of the supplier (the majority of property owners in LADWP territory) are considered to be stakeholders (Heiman and Solomon 2014, 107; “Reinventing LADWP” 2012).

Because most Los Angeles residents are LADWP customers, the bulk-purchasing model that is created enables the utilities to invest in renewable energies. As a result, municipal utilities do provide more renewable energy than private “IOU” utilities nationally (Heiman and Solomon 2004, 107). As discussed, the fact that they are public also often means that they are mandated to do so.

LADWP offers two incentive programs to residential and commercial owners in Los Angeles: the Solar Photovoltaic Incentive Program and the FiT Program (“Solar Incentive Program” 2015). Through SIP, customers can receive incentive payments for the purchase and installation costs of new solar systems; thus far, LADWP has paid out about \$237 million in rebates for about 146MW of installations, with a goal to fund 280MW (“Solar Incentive Program” 2015; “LADWP Solar Incentive Program (SIP) Dashboard” 2015). FiT allows customers to sell the power generated by their photovoltaic systems back to the grid. Though it is still in its early stages, having begun accepting applications in March 2015, 17 projects (7.9)

MW were commissioned through September 2015 (“Solar Incentive Program” 2015; “Mayor’s Dashboard” 2015).

These incentives programs have stimulated the rise of solar power in California and Los Angeles, thereby making many projects — such as the current and potential solar projects at Occidental — financially feasible.

Sustainability at Occidental.

When Occidental announced their 2015-2016 theme as “Sustainability,” a press release posted to the college’s website described the material, social, philosophical, and aesthetic importance of the concept. Over the past several years, an annual theme has been chosen to guide the required Summer Reading and Cultural Studies Program Lecture Series for incoming first years. This year, various sustainability-oriented lecturers and events have been and will be brought to campus in association with the theme (“Sustainability Initiative” 2015). However, curriculum integration, while important, is just the beginning — a true commitment to sustainability, as suggested by the literature review, requires a formal strategy and systematic methods of project implementation.

In the case of the latter, there are two existing funding mechanisms for students and faculty to pursue sustainability projects at Occidental. The ASOC Renewable Energy and Sustainability Fund was created to finance projects proposed by students that “make Oxy’s campus a better place to study and live while also combatting climate change” (“Sustainability Fund” 2015). The ASOC Renewable Energy and Sustainability Fund is composed of a group of students and overseeing faculty who host open weekly meetings. Students can submit project proposals directly to the student board via an electronic form.

Alternatively, the Board of Trustees created the Green Revolving Fund, a \$3.5 million portion of the college's endowment, in 2014 to provide loans for sustainable projects that meet an 8 percent return requirement and can pay for themselves within 12 years (Tranquada 2014). The Green Revolving Fund is overseen by a subcommittee consisting of trustee members, faculty, students, and staff (Tranquada 2014). The endowment funds used to finance these projects are paid back to the endowment using savings generated by the projects; the endowment is essentially treated as a loan that is repaid in monthly installments. In order to be considered, projects proposed by the Occidental community are vetted by Facilities, discussed by the Green Revolving Fund Committee, and then brought to the full Board of Trustees as a "reporting item," versus a traditional approval vote, according to Himmelstein.

Director of Communications Jim Tranquada concludes his press release, noting: "The Revolving Fund is the latest manifestation of Oxy's growing commitment to sustainability" (2014). He then describes the solar array currently functioning on Occidental's campus, which was approved by Trustees based on adherence to the 2013 Green Revolving Fund Requirements (which have since been updated), calling it the most visible symbol of Occidental's commitment (2014).

Current Solar Project & Potential for a New Array.

Completed in March 2013, the current array of solar photovoltaic panels installed on Mt. Fiji on the upper campus of Occidental College is producing 12.5 percent of the college's energy use. According to Occidental's website, the 4,886 panels save an estimated \$250,000 per year ("Solar Array" 2015).

However, determining the detailed payback of this project and the feasibility of another will require analysis of rebates received to pay for the initial panels, installation and maintenance (BOS) costs, and the capacity of the college's inverters. According to Moria Moe, Occidental's Premier Account Manager from LADWP, the college received a SIP rebate in June 2013 for Mt. Fiji installation. It indicated that the system would produce 999 KW AC, though an Interconnect Agreement from 2012 indicated the system would only produce 913 KW AC (Moe 2015). Determining whether Occidental is truly producing 1000KW or 1MW is important, as the campus has one inverter capable of transforming 500 KW and two inverters capable of transforming 250 KW — a total of 1000 KW. Occidental's Sustainability Coordinator, Jenny Low has described the necessity of eventually upgrading energy infrastructure on campus, noting that the Facilities department is aware of that need (Low 2015). Indeed, there are several other commonly mentioned projects that the school could pursue, such as the installation of air conditioning (AC) systems in several dormitories and long-awaited upgrades to science buildings and equipment.

An April 2015 proposal for a solar project at the Admissions Parking lot predicted that a 180.56 KW DC array would cost Occidental a total of \$516,338 (**Document F**). The estimate, performed by CSI Electrical Contractors (hereto referred to as CSI), included projected savings from LADWP incentive programs loan terms that would meet the Green Revolving Fund requirements (Renehan 2015, Tranquada 2014).

This research will modify the analysis of the 2015 proposal based on more recent data and additional information about the costs of maintenance and construction. It will also suggest alternative locations and examine community preferences regarding renewables, n focusing on the importance and feasibility of the expansion of renewable energy on campus.

RESEARCH METHODS.

Introduction.

The purpose of this research is tri-fold: first, to determine the political and social feasibility of installing an array of solar panels at Occidental College, in the context of a gradual transition to renewable energy sourcing for the campus. Secondly, to analyze data from the existing Mt. Fiji solar panels and determine the gross financial and energy savings from that investment, as well as the state of the college's current energy-related infrastructure. Finally, the researcher partnered with the Occidental Engineering club to update projections of the cost and payback for several potential locations at which solar panels could be installed on campus.

The first portion utilizes a survey intended to discern the Occidental community's opinion as to whether solar panels, and renewable energy projects in general, are a good investment for the college. The second portion of the research employs quantitative data describing the projected and actual costs of the installation, maintenance, and payback of the existing array. It also utilized qualitative participant observation sessions in which the researcher attended stakeholder meetings at which members of the Facilities Department, students, faculty, and administrators were present.

The third portion predicts the financial feasibility (costs, payback) and political feasibility (neighborhood concerns) of various potential locations on campus. It combines data from the 2015 CSI report with updated calculations performed by the Occidental Engineering Club (led by Jonathon Lamb). It also discusses the state of energy-related infrastructural equipment that may influence the feasibility of future projects. For both the second and third portion, the participant observation sessions provided data to supplement the quantitative information. **Table A** summarizes the Research Methods portion of this paper.

Table A: Research Methods Summary		
Purpose	Description	Method(s)
1. Investigate the political (or social) feasibility of additional solar installations	Determine preferences regarding renewable energy (specifically solar) expansion	Campus Climate Survey (quantitative)
2. Analyze success of current solar panels	Determine utility savings and time-to-payback	- Array data provided by Professor Daniel Snowden-Ifft (quantitative) - Participant Observation Sessions
3. Investigate the potential for solar expansion	Determine feasibility of potential locations (financial and politically)	- CSI Electrical Contractors Quotes - Occidental Engineering Club Estimates - Participant Observation Sessions - Compare Green Revolving Fund metrics
	Determine status of energy-related infrastructure on campus	- Participant Observation Sessions

Part I: Campus Climate Survey

The quantitative portion of the project was a survey distributed to students, staff, administrators, and faculty at Occidental. The intent of this survey was to gauge campus community support for an Endowment-funded transition to renewable energy, with a focus on new solar projects. It is also intended to evaluate common conceptions involving the use of the college's endowment to invest in solar panels and renewable energy projects.

The survey was distributed online via Google Forms. The purposes for using this format were to ensure that it stayed accessible within the Occidental community, as all student, staff, and faculty have Gmail-based email addresses; to encourage potential respondents to take the survey based on ease-of-access; and to allow participants to choose the location and time at which they took the survey.

The first portion of the survey relates more generally to the transition to renewable energy at Occidental — it asked participants to disclose whether they thought Occidental should invest in renewable energy sources, which types of sources they would like to see the campus

implement (i.e. solar, wind, geothermal, hydropower, other), and what they thought a reasonable renewable energy portfolio goal for Occidental might be (expressed in X percent renewable energy by 2030). The second portion asked questions related to the solar panels on upper campus — for example, whether students were aware that there currently was a solar installation and what their opinion of the array was — and the third portion referred specifically to proposed locations at the Admissions House parking lot and Braun Hall parking lot, providing a photo of each location and assessing participant support and concerns. There was also an “Additional Comments” section, where subjects had the opportunity to provide commentary in an open text box. The data was codified by the researcher and analyzed in order to identify trends. The survey is attached as Appendix **Document A**.

Part II: Analysis of Existing Solar Panels

The quantitative analysis of the panels installed on upper campus relied on the use of data collected over the past several years by Professor Daniel Snowden-Ifft (Appendix **Document B**). Preliminary information regarding the cost of installation and initial financing of the project was obtained via informal interviews conducted prior to the initiation of this research. More details regarding those data are available in the Background section of this paper.

The data includes monthly utility billing information dating back to June 1997, with specific information about high and low peak demand rates, as well as city and state utility taxes, available consistently beginning in November 2004. Because the data is consistent starting then, and because it was determined that an 11-year period was substantive enough to draw comparative data from, the researcher analyzed the period from 2004 to the present. The

researcher's focus was primarily on the differences in utility expenditures and energy usage prior to and following the installation of the panels in February 2013.

The cost of utilities and average electricity rates were recorded by Snowden-Ifft and later analyzed in comparison to the savings generated by the panels in order to determine whether the panels were effective in reducing the electricity bill, given the changing cost of energy. The data also tracked the college's energy use in relation to the total energy produced by the panels, expressed in Mwh, and the proportion of the electricity used by the college that was produced using the solar panels. This data enabled the researcher to calculate the cumulative percentage of the college's energy that has been produced by the solar panels. The savings data for the installation is available monthly beginning at the time of installation; this includes high and low peak savings, base level savings, facilities charge savings, energy savings, reactive energy savings, and cumulative numbers for each of these categories. Information about the costs and specific instances of maintenance to the panels is also included.

In addition to including the energy and demand charge savings in the analysis, the researcher included the cost of cleaning and maintenance in the analysis. Past maintenance costs for the array have been tracked by Snowden-Ifft and are included in the data used for this research.

Analysis & Economic Evaluation — Calculating Payback & ROI

The payback and ROI of the project were calculated based on current savings and compared to the values predicted for the project prior to installation. The researcher chose to use a simple payback model because, as mentioned in the Literature Review, they are ideal for clear-cut projects with shorter payback periods.

While the payback model was created using methodically recorded data, it does include estimates, whether calculated by the researcher, in the existing data, or by the utilities. Though all calculations are subject to error, those that have been estimated versus formally recorded are specifically designated as such.

Part III: Potential For Expansion

Site Analysis.

The researcher's analysis of the cost of installing a new array at various locations considered the cost of the module, installation costs, and maintenance costs, as estimated by CSI and the Occidental Engineering Club (Appendix **Documents E** and **F**). Supplementary information from the participant observation sessions was utilized to anticipate the potential advantages or disadvantages of each location.

Data from the 2015 analysis of several potential sites assesses the financial viability of projects given a 10-year, 8 percent interest loan (two years shorter than that required by the Green Revolving Fund). The Occidental Engineering Club based their square footage and wattage estimates on CSI's projections for all locations except the Braun Hall Parking Lot, which was not included in CSI's report.

For Braun Hall, the Engineering Club utilized the National Renewable Energy Laboratory (NERL) software to estimate the output of a PV system in a given area. The program uses an algorithm to predict this, given a particular area (designated on Google Maps) and project specifics (ex. module type, angle relative to the ground, inverter efficiency, etc.). Estimates for the rebates and were gathered from the LADWP website ("Incentive Levels" 2016).; carbon offset equivalency data was determined using the Environmental Protection

Agency's website and assumed a 5 hours of production per day ("Greenhouse Gas Equivalencies Calculator" 2014).

Campus Infrastructure.

The researcher also analyzed the feasibility of a new array based on the aging infrastructure of the campus, examining which other components would be necessary to achieve greater renewable energy production. Specifically, the research considered the capacity of the college's current substation, which has a 1-megawatt (MW) threshold, according to LADWP. The researcher will investigate whether this limit has been met and whether it makes sense for the college to upgrade its infrastructure to accommodate future solar expansion and other development projects. In the case that this threshold has been met, the researcher will investigate whether it makes sense to include the cost of supplementary infrastructure in the financial analysis.

FINDINGS.

The original intent of this research was to investigate the feasibility of installing solar panels at the Collins Admissions House parking lot and Braun Hall Parking Lot and gauge support for the expansion of renewables from students, faculty, staff, and administrators. Over the course of the research, it became clear that there were more than two locations on campus that had potential as future solar sites; it also became clear that it may be feasible to install panels at any or all of these locations, eventually. While the survey focuses specifically on these two locations, the "Potential for Expansion" section also considers alternative locations. Data and analysis in this Findings section is divided into three parts: survey responses, evaluation of the

current solar array, and an examination of the possibility to expand solar. The “Potential for Expansion” section considers the current infrastructure on campus that impacts renewable expansion and evaluates the financial and political feasibility of various locations.

The latter two sections utilize information gathered in participant observations sessions, various meetings between Facilities Management staff, administrators, faculty, and students (**Appendix Document H**), to supplement data gathered by stakeholders (**Documents B-G**). Much of the information regarding the future of solar panels and renewables at Occidental was collected through participant observation. As this research evolved, it triggered a process at the college level in which stakeholders began discussing the plausibility of installing additional solar. As such, the researcher became a participant in these meetings. Though the identities of the participants will remain anonymous, except where given explicit permission by the individual, the following information is accurate and comprehensive to the fullest extent of the researcher’s knowledge. **Table B** summarizes the Findings section of this paper.

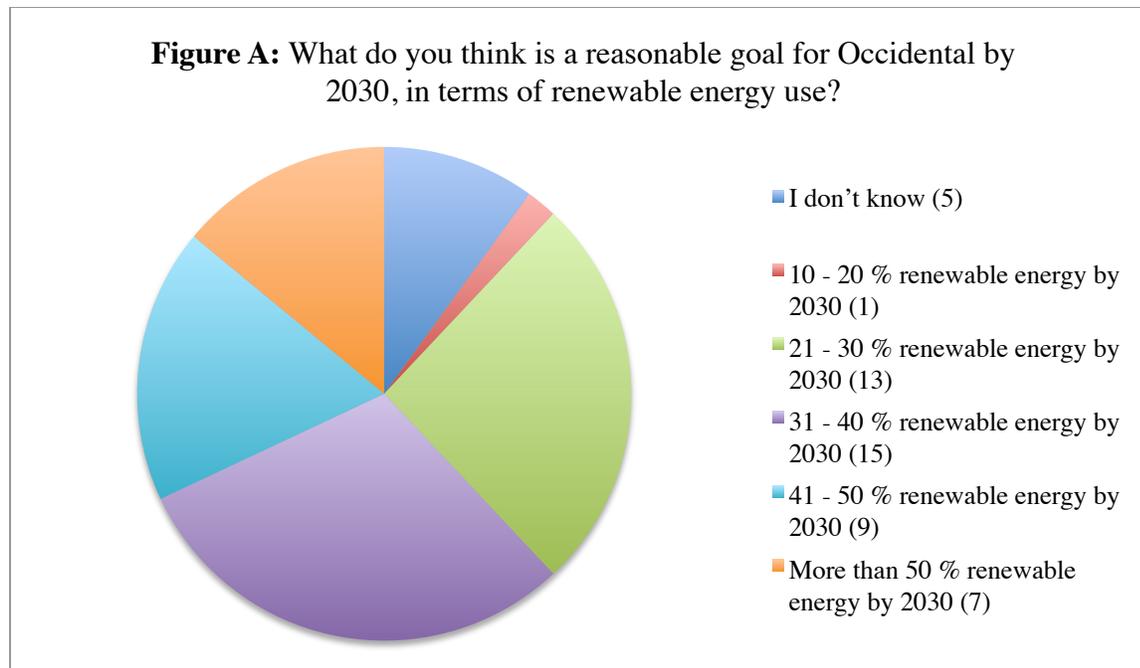
Table B: Findings Summary	
Section	Key Findings
1. Campus Climate Survey	<ul style="list-style-type: none"> - One hundred percent of those surveyed indicated a preference for continued investment in renewables - Majority of respondents supported goal of 31 percent or greater renewable energy use at Occidental by 2030 - 54 percent of students indicated their knowledge of sustainability initiatives on campus impacted their desire to attend Occidental - Though every respondent was aware that there is currently an array, 36 percent of students felt they did not have enough information to form an opinion about it
2. Evaluation of Current Solar Array Data	<ul style="list-style-type: none"> - Final cost of the panels to Occidental: \$3.935 million - 20 percent has been paid off through utility savings, to date; they are expected to pay for themselves within 17 years - The system currently offsets 12.5 percent of Occidental's usage - Because of the array, Occidental's utility bills have decreased, even as rates continue to rise - The array has produced 5.5 GWh since its installation, saving the college approx. \$776,416.26
3. Potential for Expansion Part I: Infrastructure on Campus	<ul style="list-style-type: none"> - Majority of energy infrastructure is at capacity - Addition of any new panels would require the college to replace substation, installing a Solar Vista Switch (expected cost: \$750,000) - Without replacement, there is also little room for other on-campus developments, including planned AC expansion - A 166kW array would offset the carbon emissions created by planned AC expansion - Financing Opportunities: Green Revolving Fund, grant or loans, switching to co-Gen rate, Alumni donations, ASOC Renewable Energy & Sustainability Fund
3.5. Potential for Expansion Part II: Potential Site Analysis	<ul style="list-style-type: none"> - Identified 5 locations in 3 categories: roof tops, parking lots, and Avenue 50 land - Many small projects are only feasible if the substation replacement is not considered in cost analysis - Larger projects are more likely to face neighborhood concern

Campus Climate Survey.

The campus climate survey was distributed on January 25, 2016 with the intent to gather information on the preferences and opinions that individuals on campus held regarding sustainability and renewable energy investment. While the researcher's intent was to collect survey responses from faculty, staff, administrators, and students, the response rate for non-students was extremely low. As a result, responses submitted by non-student survey participants were not included in the Findings section of this paper. A full version of the survey questions is attached as Appendix **Document A**.

Excluding non-student participants, the survey had 50 respondents. According to the Occidental College website, there are currently 2,117 students enrolled; thus, the response rate was approximately 2.4 percent of the population size.

A majority of these students (62 percent) indicated that a reasonable renewable energy goal for Occidental to achieve by 2030 would be 31 percent or greater (See **Figure A** for complete distribution). One hundred percent of those surveyed indicated a preference that Occidental continue to invest in renewable energy.



The data suggests that many students are interested in sustainability on campus — particularly prospective students: 54 percent of Occidental students indicated that their “knowledge of sustainability initiatives on campus [impacted their] desire to attend Occidental” — relatively close in comparison to the Princeton Review’s 61 percent of students referenced in the Literature Review of this paper. Of the surveyed population, 16 percent of students indicated that information regarding sustainability did not affect desirability at all. However, 18 percent felt that their knowledge of the college’s commitment contributed “Very Much” or “Strongly” to their decision.

Meanwhile, current students expressed a desire to become more informed about sustainability initiatives on campus. Because a large portion of this research relates to the success of the current panels, respondents were asked about their awareness and opinion of that installation. Every respondent was aware that there was currently an array on campus; 58 percent of respondents designated that they were pleased with the current array. When given the opportunity to express that they did not have enough information or interest to answer the

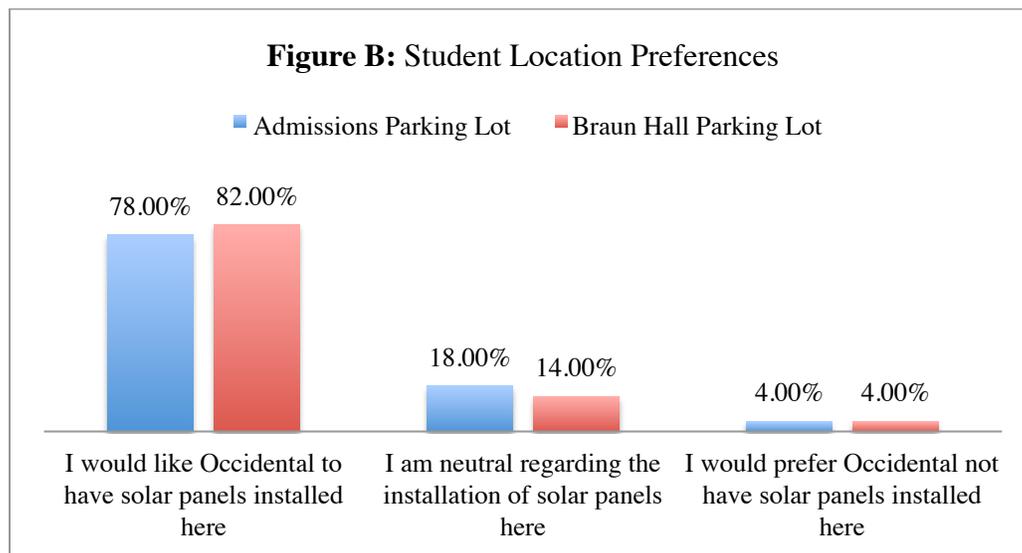
question, a significant number of respondents selected this option (36 percent specified “I do not know enough about it [the current installation] / I do not have an opinion”). In the “Additional Comments” section, several respondents — 20 percent of those who utilized this optional comments section — stated a desire for the college to make information about the current installment more available.

Interestingly, when asked about their concerns regarding two potential sites for solar panels, several respondents *did* express concerns (18 percent for Admissions Parking Lot location; 24 percent for Braun Hall Parking Lot location), signifying the social desirability bias was low. Expense was the primary concern expressed regarding the Admissions location, with 10 percent of respondents indicating concern. For the Braun Hall location, convenience (8 percent) and aesthetics (6 percent) were the principal concerns.

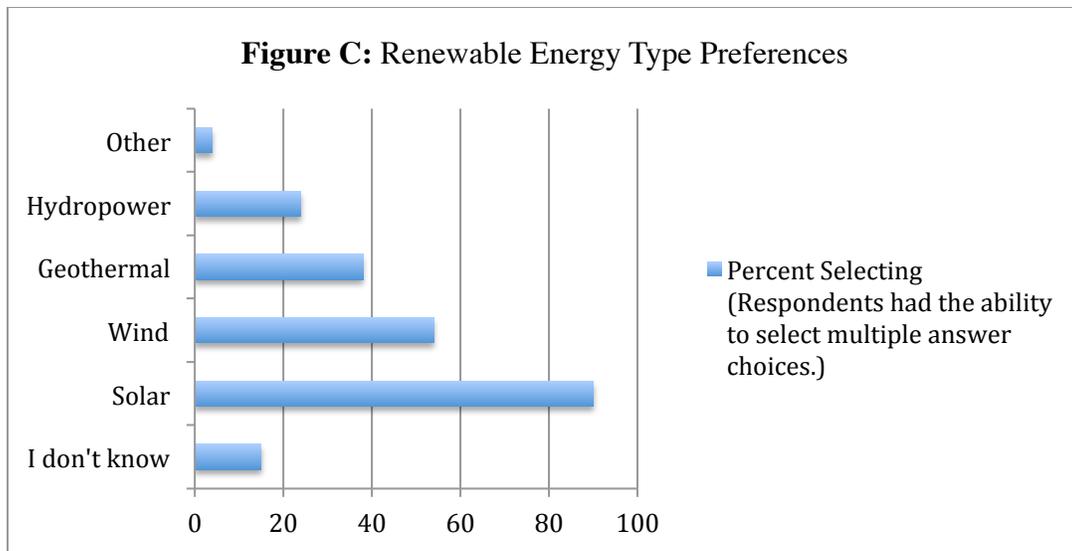
Only one respondent was opposed to the expansion of solar: in the “Additional Comments” section, this individual clarified that they considered solar to be inefficient (due to Occidental’s focus on aesthetic design, which they understood lowered the efficiency), non-profitable, and environmentally damaging. This individual preferred panels not be installed at either location and was not pleased with the current array. Another respondent also clarified that their reasoning for expressing discontent with the current array pertained to their understanding that the panels could have been more efficient, though this respondent was in favor of future projects at either location.

In either case, the great majority of respondents indicated that they would like to have solar panels installed at the Admissions (78 percent) or Braun Hall (82 percent) parking lot and that they had no concerns (82 and 76 percent, respectively). The fact that more participants favored the Braun Hall location over the Admissions location, despite a higher percentage of

respondents expressing concern over the latter, is qualified by the detail that there was a slightly higher percentage of respondents who were neutral about the Admissions location. For both locations, only 4 percent of respondents indicated they would prefer not to have solar panels installed (**Figure B**). This represents a combined 3 participants, as only one participant responded negatively to both locations.



Though solar was the preferred type of renewable energy (92 percent expressed a desire for continued investment in solar), more than half (54 percent) of participants were supportive of the college investing in wind power (Figure C). The 4 percent of respondents who did not indicate they would like to see an investment in solar (excluding those who answered “I don’t know”) all chose both wind and geothermal. Interestingly, each individual in this group also expressed content with the current panels and a desire to install additional panels in both locations, identifying no concerns with either location.



Overall, the survey results suggest a vested student interest in solar energy and an even stronger desire for the implementation of renewable energy of any variety. Many of the comments also suggested that students would like to receive more information from the college regarding sustainability projects.

Survey Methodological Considerations

Due to the means of distribution, which are outlined in the Research Methods portion of this paper, there likely exists some bias in the response group toward individuals who tend to take online surveys, read the Oxy Student Digest, or knew the researcher personally. There also may be bias simply in that students choosing to respond to a study entitled “The Sunnier Side: Feasibility of Solar & Renewable Energy Expansion at Occidental” would have a vested interest in renewable energy investment (or at least perceive that the researcher would expect them to

answer questions a certain way). However, the fact that not a single respondent preferred that the college stop investing in renewables speaks strongly.

Additionally, the responses to the questions regarding students' concerns about potential solar projects and the overall usage goals for the campus may be skewed. In the case of the former, the answer options for concerns about each location, such as "I think initial expenses are too high" and "I don't like the aesthetic," may have been confusing, given that the average participant may not have any idea what the order of magnitude for solar panel pricing is or what the proposed solar panel installation would look like. A similar issue applies to the question posed about Occidental's overall goals for implementing renewable energy — a participant who has little or no experience with renewables may not understand the implications of or difference between a 20 percent commitment and a 40 percent commitment.

Evaluation of Current Solar Array Data.

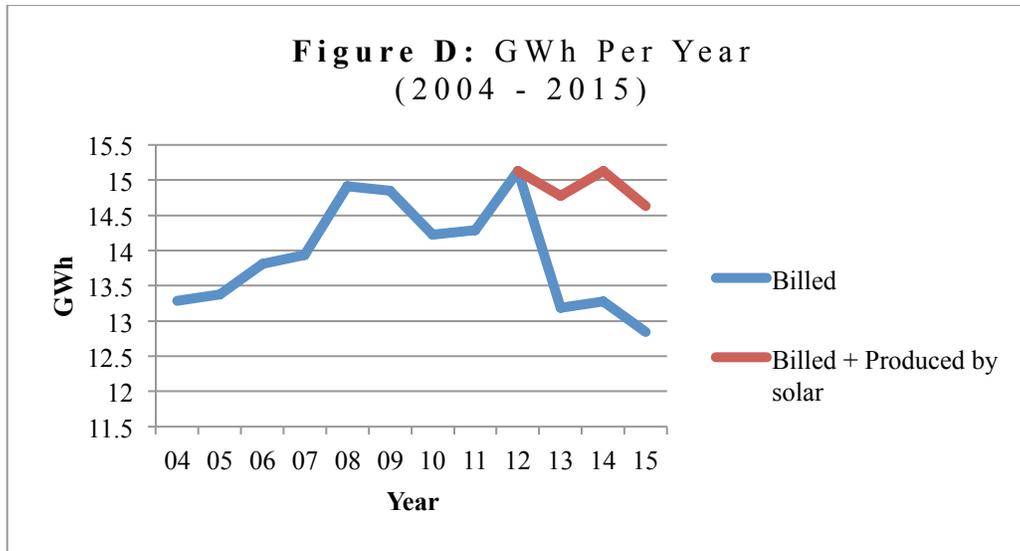
Data regarding the energy production, annual energy bills, savings information, and projections for the payback period of the current panels are included in this section (**Document B**). Those data were compiled by Snowden-Ifft, as outlined in the Research Methods section of this paper. Information gathered during the participant observation sessions has been included to supplement and explain trends in data and clarify the project timeline.

The total original cost of the existing solar array on Mt. Fiji was \$7.212 million, including both direct and indirect costs. Following an LADWP SIP rebate of \$3.277 million, applied in June 2013, the final cost of the project to Occidental was \$3.935 million. Maintenance of the panels (cleaning, weeding, and CSI maintenance) has totaled \$31,358.42 over the installations lifetime, accounting for about .32 percent of the college's annual energy expenses.

Construction lasted 15 months, following a two-year land use approval and design process. On March 4, 2013, the panels were switched on and began generating power. Since that date, the panels have begun to pay for themselves — 20 percent of the array has been paid off due to utility-cost savings to date. The system currently offsets 12.5 percent of Occidental's campus energy use.

According to the calculations provided by Snowden-Ifft, the panels will pay for themselves within 17 years, assuming that LADWP rates continue to rise at a rate of 5 percent annually. The 5 percent estimate projects a continuation of the average annual LADWP rate increase from 2004 to 2015. His most recent calculation estimates 16 years to payback with an assumed a rate of 6 percent annual utility cost increase. This is a conservative estimate, according to a separate stakeholder, who indicated that LADWP was expecting rates to rise by as much as 7 percent annually in the near future. When the panels were originally proposed to the administration in 2012, Snowden-Ifft calculated payback based on a 3 percent annual increase (still conservative for that year). The result of rising utilities rates, amongst other factors, is that the panels are likely to pay for themselves over a shorter period than originally expected.

Though the college's overall energy usage has remained relatively stable since the installation of the current array, the advantage of the added solar is that Occidental's utility bills have decreased, even as rates continue to rise. **Figure D** demonstrates these savings in another way, showing the number of gigawatt-hours (GWh) used by the college (24.63 GWh in 2015) that were produced by the panels, which the college would otherwise have been charged for.



This year, the array produced 1.80 GWh of power, bringing total production to 5.5 GWh over the last three years. This has saved the college approximately \$233,502.17 in utility costs over the last year and \$776,416.26 throughout the array's lifetime. **Table C** describes the total production and cost of the panels since they came online in March 2013. The reduced production (and therefore reduced savings) for the 2015 - 2016 year reflect an incident in May 2015 that caused the main inverter to fail.

Occidental's current panels have never produced more energy than they consume, and stakeholders estimated that there are not enough potential sites on campus for the college to produce more power than is consumed. This rules out revenue-driving options, such as selling energy back to the grid to help utilities meet their Renewable Portfolio Standard (RPS) goals.

Table C: Fiji Solar Array**Production & Savings**

	Energy Production	Utility Savings
Year 1	1.82GWh	\$249,633.26
2013 - 2014		
Year 2	1.88GWh	\$293,280.82
2014 - 2015		
Year 3	1.80GWh	\$233,502.17
2015 - 2016		

Potential for Expansion Part I: Infrastructure on Campus.*Overview*

Much of Occidental's existing energy-related equipment is at its limit in terms of capability — the 3 current inverters, the Main Switch, and the four feeder lines are all at full or nearly full capacity, and much of that infrastructure is considerably aged.

The substation is composed of the Main Switch and a transformer. It receives 34.5 kV of DC electricity from LADWP power lines, transforms the power into 4.8 kV of AC, and then distributes that electricity to Occidental's feeder lines. A diagram is included as Appendix

Document C.

Occidental's inverters have a maximum output capability of about 1 MW. The system is currently producing 1.142 MW DC and 1.012 MW AC, meaning that the addition of any new panels would require the college to replace the inverter. The reasoning for this is not

arbitrary: LADWP has an internal policy requiring customers producing over 1 MW of solar power to install a Solar Vista Switch at their substation inverters. The Switch enables LADWP to disconnect Occidental's substation from the grid at any given time, in order to avoid situations where excess power is back-fed into distribution lines. Though there is a remote terminal unit (RTU), which automatically switches on when queued by a switch built into solar array systems, the Switch is also a manual on-site switch in a box. The Solar Vista Switch comes as a unit containing both a transformer and the Switch and would replace the existing substation. Currently, Occidental's Main Switch is both at capacity and at the 40-year mark for suggested replacement.

Substation Replacement Cost Analysis

The necessity of a new inverter for expansion would suggest that the researcher should calculate the cost of that inverter into financial analysis for each location. According to LADWP, the cost of a new substation equipped with a Solar Vista Switch is divided into three portions: the hardware of the Vista Switch itself (\$200,000), the LADWP charge for installation and cabling (est. \$100,000-200,000), and the cost of additional infrastructure, such as the concrete pad on which the transformer is mounted (a high estimate is \$300,000). A high, all-inclusive estimate is \$750,000, according to LADWP. Dependent on the location selected for a new solar installation, connecting panels to the substation could be expensive. Thus, the payback period would likely be significantly extended, and in many cases, this would make funding through the Green Revolving Fund unachievable.

Additional Benefits of Replacement

However, substation replacement offers additional benefits. Occidental is growing — amongst other projects, stakeholders identified retrofits and upgrades to the Biology Building, Taylor Pool, and the tennis courts as priorities for Facilities Management. Perhaps the most significant “other” is the addition of AC systems to five dorms: Stearns, Chilcott, Haines, Stewart, and Pauley. Aside from cost, aging infrastructure and inadequate capacity pose the main barriers to this project. Many of the four feeder lines (if not all — a test needs to be conducted in the near future), including those that would link to the aforementioned dorms, are at maximum capacity. Without replacing the substation to increase capacity, there is little room for expansion or development on campus, including the installation of additional AC systems.

Indeed, it may be that a substation replacement is necessary regardless of the addition of solar panels — and soon. As previously noted, AC expansion in the five dorms has become a priority for Facilities Management. These developments would likely happen at a rate of one building per year. At this point, the college does not have an estimate for the expected energy use of the proposed project; however, Facilities is in the process of determining this information through a Mechanical Contractor and Electrical Engineer. As of March 3, 2016, Facilities Management had sent a Request for Proposal (RFP) to the college’s Financial Department, who will determine whether funds are available for the project and whether it makes sense to pay for a more comprehensive Feasibility Study.

Snowden-Ifft roughly estimates the AC energy usage to be 300,424 kWh/year for all five dorms (**Document D**); if this is the case, the college’s energy use will increase by 2.1 percent. A 166kW solar array would reduce consumption and carbon emissions by an equivalent amount.

Because no engineers have been to the site to perform specific calculations, these estimates are very preliminary and should only be used as an order of magnitude.

Carbon Offsetting & Payback Considerations

It is inevitable that the substation be replaced in order to accommodate the additional AC. It is also inevitable that the cooling system will increase the amount of energy used — and carbon emissions produced — by Occidental. As solar panels reduce carbon emissions, there is an opportunity to offset the added emissions through the installation of solar panels. According to Snowden-Ifft, the current panels have reduced our carbon dioxide emissions by 3,793 tons to date, enough to power 339 local homes for three years.

In the case that the college does purchase a new inverter to support development projects such as AC, only the cost of choosing a model with a Solar Vista Switch should be included in the financial analysis of potential sites (versus the total cost of the substation). Stakeholders agree that it is difficult to determine the cost difference between a Solar Vista and non-Solar Vista substation without an engineering study of the campus, as the equipment has various site-specific sizes and configurations that impact pricing. If we are to include the cost of the Solar Vista Switch, the time added to payback is calculated by dividing additional cost of the Switch by the amount saved annually given a potential installment.

Financing Options

Occidental has existing mechanisms intended to finance potential projects, as well as access to utility rebates, grants, and loans. Though funding for renovation and building projects has been taken from the Endowment before, Trustees generally prefer to keep funds growing

where they are currently invested, according to Himmelstein. He described that removing money from the Endowment is difficult, regardless of the nature of a project. This is partially due to the fact that 5 percent of the Endowment is allocated to Occidental's Operating Budget — if the total amount of money in the Endowment decreases, the college's Operating Budget decreases.

Because the Board of Trustees has “a lot of competing needs,” the Green Revolving Fund was created to help streamline funding for sustainable projects — if the projects meet certain financial metrics. As mentioned in the Background section of this paper, the qualifications are that the project must produce a return of 8 percent or greater and have an estimated payback period of 12 years or fewer. According to stakeholders, payback is considered to be 110 percent of the cost of the project, as the fund is a loan and therefore charges interest.

The Green Revolving Fund subcommittee is comprised of: the Vice President for Finance and Planning, a Trustee from the Budget and Finance Committee, the Director of Facilities, the Director of Energy Services, the Sustainability Coordinator, and two faculty representatives.

If the Green Revolving Fund is not sufficient to cover the cost of expansion (or if future projects do not meet the requirements), Himmelstein indicated that the Board of Trustees may be open to pursuing grant or loan options, citing a recent tax-free bond from the California Education Facilities Authorities (CEFA) that was utilized to finance the Central Chiller Plant. In the case that the college took out a loan, Himmelstein suggested a preference for setting up payments based on monthly recurring revenue (MRR), wherein the savings from each month could be used to make a loan payment of the same amount. This presents a challenge for solar projects, which don't generate the exact same amount in savings each month. There is the possibility of finding an industry lender who is able to accept slightly varied monthly payments based on the savings accumulated during that period of time.

Additionally, LADWP customers producing more than 1 MW of power are charged a Co-Generation utility rate, versus the default net energy-metering (NEM) rate. However, calculations by Snowden-Ifft, which have been reviewed by LADWP, suggest that Occidental could actually reduce utility costs by as much as \$20,000 by switching from an A-3A to a CG-3A Co-generation rate (Document E). The basic rationale is that Occidental can save money because the extra Backup Capacity Charges (which guarantee power via a spinning reserve and LADWP requires customers to have in the event that the on-site generator has issues) are counteracted by the decreased Demand Charge rates. As the calculations based on data from 2015 suggest that this is the case, the college would likely realize greater savings given the production of additional power. LADWP has the ability to switch Occidental to a CG-3A rate.

Another avenue that has not been explored for solar or renewable expansion is the use of the college's Alumni network; through the Institutional Advancement's TeleFund program, Alumni currently have the ability to donate to specific projects and programs.

In early discussions, constituents identified the ASOC Renewable Energy & Sustainability Fund as a source of funding, though it became clear early on that the group would not be able to supply adequate funds. However, there is an opportunity to utilize ASOC monies to reduce the cost of maintenance and other expenses associated with the installation.

Himmelstein believed the Green Revolving Fund was the quickest path to financing. The researcher expressed that the substation replacement, though it could be tied onto a solar project, is also a project that the college would eventually need to invest in. Himmelstein acknowledged the added benefit and noted that the necessity of the substation was something that could be weighed into the Green Revolving Fund's decision.

Potential for Expansion Part II: Potential Site Analysis.

In this section, several documents were compiled to provide a comprehensive analysis of potential locations. Given the possibility of installing the panels as a carbon-offset mechanism, the researcher worked with students on Occidental’s Engineering Team to calculate the size, cost, and carbon savings equivalency for various potential sites (**Document G**) in an attempt to update the projections provided by CSI in 2015 (**Document F**). The Engineering Club asserts that their calculations are estimates and that actual projections would need to be performed by a professional engineer. If the college wishes to offset emissions, any combination of these sites could be utilized — either for the AC expansion or future development projects. Participants identified three main categories: rooftops, parking lots, and a property on Avenue 50 that is owned by the college — **Table D** summarizes the specifics for each site. Stakeholder comments regarding each location were also included.

	Size	Rebate	Final Cost (Including Rebate)	Carbon Equivalency (in metric tons)
Mary Norton Clapp Library (Rooftop)	36.6 kW	\$14,640	\$113,460	46.1
Chilcott Hall (Rooftop)	27.45 kW	\$10,980	\$85,095	34.5
Collins Admissions House (Parking Lot)	180.56 kW	\$72,224	\$650,016	227
Braun Hall (Parking Lot)	196.6 kW	\$78,640	\$648,780	247
Avenue 50	228 kW	\$91,200	\$558,810	287

*Assumes Step 8 Incentive Levels

Structural integrity is the main barrier facing rooftop installations at Occidental. Though the Rush Gym rooftop was brought up several times as a potential location, it has not been included in this report due to proof of insufficient structural support. The roof of the *Mary Norton Clapp Library* was assessed by CSI in 2015, and the contractor determined the location

was suitable for a 36.6 kW array. Their quote estimated a total cost of \$128,100, or \$3.50 per watt. The Engineering Club estimates that this would cost Occidental \$113,460 following an estimated LADWP rebate of \$14,640. It would offset 46.1 metric tons of carbon dioxide emissions annually. CSI also examined the roof of *Chilcott Hall*, where a 27.45 kW installment could be installed for \$3.50 per watt, or \$96,075. Garnering an estimated rebate of \$10,980, the total cost to Occidental would be \$85,095. The Chilcott Hall roof, the smallest proposed location, would offset 34.5 metric tons of carbon emissions annually.

Notice that both rooftop locations are of similar size and cost the same amount per watt. Both would not be visible from the ground, meaning that aesthetic concerns are not a threat to either the community or the potential efficiency. Though they are not expected to save as much money as other options in the short-term, the low initial cost of the panels will enable Occidental to show commitment to sustainability and realize long-term savings with relatively little money down.

Stakeholders also identified several parking lots as potential sites, including the Collins Admission House parking lot and Braun Hall parking lot. CSI's estimate for the *Collins Admissions House parking lot* is \$722,240, or \$4.00 per watt. With an expected LADWP rebate of \$72,224, the total cost of the 180.56kW installment would be \$650,016. The carbon savings equivalency would be 227 metric tons annually. Stakeholders agreed that an advantage of this location would be its visibility to prospective students.

Though the *Braun Hall Parking Lot* was not assessed by CSI, the Engineering Club estimates its total initial cost to be \$727,420. Following \$78,640 in rebates, the 196.6kW installation would cost the college \$648,780 and offset 247 metric tons of carbon emissions per

year. Either of the parking lot arrays could be installed as a carport and, like the current array, could also have the capability to charge electric vehicles.

The largest of the proposed locations is the *Avenue 50* lot. The college-owned property is flat and undeveloped. CSI's 2015 report quoted an array producing 228kW of power at \$650,010, or \$2.85 per watt. With a potential LADWP rebate of \$91,200, the total cost to the college would be \$558,810. The large project would offset an annual 287 metric tons of carbon emissions. The price includes the cost of more secure wiring, which is necessary to connect this more remote location to the campus grid and assumes that no trees will be removed from the slightly wooded area. This location is unique in that, given its size, CSI estimated that the savings could also pay for the full substation replacement while staying within the Green Revolving Fund investment metrics. However, as an undeveloped site, the use of this site would require college administrators and likely the Board of Trustees to agree that solar power production is the best use of the land. Before moving forward, it is important that an engineer assess the site, as a gully underlies portions of a manually filled slope on the property.

Using a tool configured by the NERL, the Engineering Club's report estimated an 11.87 percent loss in power from natural phenomenon (such as shading, soiling, and weather) and age-related phenomenon (such as light-induced degradation, wiring, and connections) given the location of Occidental's campus. The club also theorized a high range in efficiency depending on module type (9 percent), further increasing the uncertainty of predictions.

Many of the smaller projects are rendered unfeasible when the cost of the new substation is included in the financial analysis. In this case, only larger projects would meet the Green Revolving Fund requirements. Once the new substation is installed, many of the smaller projects

are able to meet the Green Revolving Fund specifications, meaning that additional future expansion is financially feasible.

Unfortunately, the larger projects pose more of a challenge in terms of permitting. Were any of these projects to be implemented, it is likely that they must first be approved by the city. In order to streamline this process, which includes a public comment period, participants identified the proactive proposal of the project to the community as a top priority. As was the case with the current panels, community concerns are expected to pose a significant barrier.

The existing solar array exemplifies the complexity of this: the panel design could have been more efficient, but neighborhood concerns incentivized the selection of non-rotating and aesthetically pleasing alternatives to the most effective models available at the time.

Stakeholders suggested that a model of what the panels would look like and the extent to which they would be visually distracting (whether in terms of reflectiveness or aesthetics) be provided to the community well in advance.

For any given solar installment, stakeholders estimated a timeline of approximately two years, allocating about 18 months for design and 4-6 months for construction. The campus would need to be shut down for one day in order to bring a new panel online.

RECOMMENDATIONS.

Table E: Summary of Recommendations	
Tier 1: Quick Fixes	Tier 2: Long-Term Tasks
<ul style="list-style-type: none"> - Replace substation with a Solar Vista Switch model - Calculate energy consumption for AC project to determine which solar projects could act as offsets - Continue to analyze savings and payback of Fiji array - Propose that ASOC Sustainability Fund supplement maintenance costs of solar - Determine alternate sources of funding, particularly potential for Alumni donations 	<ul style="list-style-type: none"> - Offset all major development projects with renewable energy projects to establish carbon-neutral expansion <ul style="list-style-type: none"> - Research potential locations for other forms of renewable energy, such as wind - Create a plan to work with community and minimize conflict associated with expansion - Student activists should target and garner support from Green Revolving Fund Committee, high-level administrators, and Board members

Based on the researcher's findings, it is abundantly clear that — solar or no solar — the college is in need of a substation replacement. Provided that the cost of a substation with a Solar Vista Switch is not substantially higher than the cost of one without it, it would be financially reasonable and realistic for the college to select this model. The installation of a Solar Vista Switch substation would enable the campus to expand energy use *and* solar use in the near future and at later dates.

The argument for a prompt expansion of solar is manifold. Aside from the inherent financial case — the sooner the panels are installed, the sooner the project will begin to generate payback and save the college money — there is the added advantage derived from current and prospective students, who have a vested interest in increased sustainable initiatives on campus. Finally, as the college continues to develop its infrastructure and renovate older buildings, a new solar installment could offset the additional energy use and carbon emissions these projects would produce. The most immediate example of this is the expansion of AC throughout older dorms. Once Facilities has calculated the energy required for (and therefore carbon footprint of) that project, it is the researcher's hope that the savings data generated in this research will allow stakeholders and decision-makers to install a solar project at any of the proposed locations

necessary to “offset” the increased emissions. Snowden-Ifft’s preliminary calculations suggest that the energy usage for AC in all 5 dorms could be offset just with the installation of panels at the Collins Admissions House Parking Lot.

Over time, this concept of offsetting development with renewable power generation — solar or otherwise — would allow Occidental to achieve carbon-neutral expansion. The research indicates there is a policy incentive, a financial case, and a student mandate for the college to make a formal commitment to investing in carbon offsetting renewable energy projects for every major development project. It is possible that this commitment would lead Occidental to expand its renewable energy portfolio to the student’s plurality preference of 31 - 40 percent by 2030; it is probable that it would reach the second most popular selection of 21 – 30 percent by that date.

The use of the Green Revolving Fund to finance these projects would also eventually increase the proportion of the endowment invested in renewables; even if the college does not divest completely from fossil fuels, this is a step in the right direction. The literature review indicated that student groups should target administrators, whose support was often one of the strongest advantages. While top-down influence was often necessary to complete these projects, bottom-up organizing played an important role in making climate change a priority for the college. Student activists should target key administrators and Board members in addition to the members of the Green Revolving Fund Committee.

The research suggests that the solar and wind power, in particular, make sense given their cost feasibility, success in Los Angeles climates, and approval from research participants. Future research should be completed to determine which locations are ideal for wind and other renewable power generation projects.

It is also important to continue analyzing the current panels' performance, costs, and savings on a monthly basis. This information is essential in planning and promoting additional installations on campus. Eventually, as these panels begin to “expire,” they will provide data regarding end-of-lifetime solutions that can further guide investment and design.

For any projects that require a zone change and/or are subject to a public commitment period, the researcher highly encourages working with the surrounding community to minimize conflict. As was the case with the current panels, prioritizing the aesthetics of the design can often lead to slightly less efficient arrangement. The challenge will be to select panel designs that maximize efficiency while remaining visually appealing to neighbors. Rooftop options, which are generally invisible to the surrounding community, present less of an issue and could therefore be used to mitigate any efficiency lost in more visible installations. Public involvement should begin as early as is reasonable; suggestions include providing a model of what the project would look like and an FAQ document outlining common concerns, such as details regarding sun reflection and the construction process. It is also advisable to bundle the project with another development project — for example, planning coinciding Conditional Land Use Permits for the upcoming renovations of Taylor Pool or the tennis courts. Eventually, renewable energy projects could be bundled with the new development that they are intended to carbon neutralize.

While financing projects at many of the proposed sites is feasible within the terms of the Green Revolving Fund, the college can pursue outside funding. The researcher suggests further exploration into the availability of industry lenders who are able to accept slightly varied monthly payments based on the savings accumulated during that period of time. Ultimately, though, tapping into Alumni networks may be the most effective source of external financing. It would be relatively simple to start a Telefund campaign that targets donors

interested in sustainability (those working in the sustainability sector, those who have donated to environmentally-oriented projects in the past, UEP majors, etc.) or adds information about the college's commitment to carbon neutrality to their regular calling script. Donations would minimize the cost and payback time, increasing the feasibility of projects considerably.

Maintenance costs could be paid using the ASOC Renewable Energy and Sustainability Fund; this would need to be proposed to and approved by that group in the future.

Finally, whether or not there is any expansion of solar, the college can benefit financially by switching to a Co-Generation rate (specifically, CG-3A). As previously mentioned, this would save about \$20,000 if the rates switched at the time of the research, with only the panels on Mt. Fiji generating energy. Given the expansion of renewable energy production in the future, the savings from this switch will continue to increase.

CONCLUSIONS.

In a greening economy stimulated by a darkening climate change situation, some may say that there is a huge potential for college campuses to act as testing and training grounds for a new generation of 'green collar' workers. Others might say that there is an incentive for colleges to do so, based on the fact that utilities providers and government policies have implemented various policies to make such missions affordable. However, this research indicates that there is a *mandate* for colleges, given the nation-wide student interest in attending colleges with sustainable projects and initiatives.

As an institution boasting various commitments to greening campus and a sustainability-themed school year, it is important that Occidental develop a long-term plan for incorporating

environmental projects into their structural processes. Preliminary actions to do so have resulted in the development of the current solar installation, the Green Revolving Fund and ASOC Renewable Energy and Sustainability Fund, the Sustainability Coordinator position, and the Sustainability school year theme, amongst others.

This research examined the financial and political feasibility of expanding solar power generation on campus. It also investigated the ways in which institutions with aging infrastructure can attain a renewable energy portfolio. These questions were operationalized through a student survey, an examination of the current solar array and energy-related infrastructure (including existing financing systems), and an analysis of potential sites for solar expansion.

The survey found that the presence of sustainability initiatives was significant for potential students, a majority of whom specified that Occidental's commitments impacted their decision to attend. It also suggested a high demand for the expansion of renewable energy amongst current students, who favored solar and wind projects. A majority of students also indicated that they would like to see Occidental produce at least 31 percent of its energy through renewable sources by 2030. Finally, survey participants specified in a variety of ways that they would like to receive more information from the college regarding the current panels and renewable energy initiatives in general.

Through the analysis of billing, savings, and maintenance data collected for the current panels and supplemental participant observation sessions, the researcher determined the total cost of the current array to the college (\$3.935 million), the savings to date (12 percent of overall energy use; \$776,416.26), and the estimated time to payback (17 years, conservatively).

The evaluation of current infrastructure — primarily, the substation and feeder lines — led to the finding that much of the college's electric infrastructure is over capacity and over-aged. It was also determined that the 1MW limit is both preventing the expansion of solar and inhibiting larger renovation projects. If the substation were to be replaced with a version containing a Solar Vista Switch, both solar and rehab projects could be undertaken.

Politically, it is sensible to frame renewable energy projects as carbon offsets to development projects, as current students, potential students, and community members may be more likely to support carbon-neutral expansion. After calculating carbon emissions of new development projects, such as expanded AC in dormitories, the researcher suggests that Occidental commit to a renewable energy project on campus that is estimated to reduce the college's footprint by an equivalent amount, such as a solar photovoltaic system. The five potential locations reviewed here represent only a portion of the available locations and focuses only on those that are ideal for solar.

Even in the case that solar development does not happen within the next two years, the substation will need to be replaced. It simply makes sense to install a Solar Vista Switch at the same time the new substation is installed, so that if the school decides at any point in the life of the new substation to implement additional renewable power, the infrastructure is there. Installing the Switch now would mean the college would not have to pay again for the labor and equipment and hear community concerns.

It does, however, appear that there is an opportunity to propose solar in conjunction with a quickly approaching AC expansion. On March 15, 2016, stakeholders from the participant observation sessions met to discuss the future of solar at Occidental. Given the supportive research of various stakeholders, as well as the potential to offset emissions for the AC project,

the group collectively decided to move forward. Their goal is to develop a short Letter of Intent by the end of the year, which will be presented to the Green Revolving Fund Committee; if the Committee agrees to see a proposal, a more in-depth description of the suggested project will be prepared.

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Document A: Survey Questions

The Sunnier Side: Feasibility of Solar & Renewable Energy Expansion at Occidental

* Required

Student Investigator: Chloe Woodruff
Faculty Supervisor: Bhavna Shamasunder
Title of research project: The Sunnier Side: Feasibility of Solar & Renewable Energy Expansion at Occidental

You are invited to participate in a research study conducted by Chloe Woodruff, a student from the Urban and Environmental Policy Department at Occidental College, as part of her senior comprehensive project. You must be at least 18 years of age to participate in this study.

The objective of this research project is to determine the feasibility of installing an array of solar panels above the Dennis and Mollie Collins Admissions House parking lot at Occidental College. The intent of this survey is to gauge student, staff, faculty, and administrator support for such a project and provide these individuals the opportunity to comment on the development. It is also intended to discern the Occidental community's opinion as to whether solar panels, and renewable energy projects in general, are a good investment for the college.

Participation in this research project is completely voluntary. If you agree to take part in this study, you will be asked to complete an online survey which should take about 10 minutes to complete. It is expected that participation in this survey should cause no more risk than encountered in daily life, the exception being if you feel uncomfortable sharing your thoughts on this subject. However, you may stop taking the survey at any time with no penalty to you or loss of benefits to which you are otherwise entitled.

Your responses will be kept anonymous. Participants will only be referred to by their position at Occidental College (ie. student, staff, faculty member) in the final report of this study, which may be used in presentations and publications. In addition, if you are interested in the final results of this study, please email the researcher at woodruff@oxy.edu to request a copy of the final report. The data collected from participants may be held for future use, and may be stored, re-analyzed, or otherwise combined with other data at a date after the specific period defined by this study.

If you have any questions about this study, please contact Chloe Woodruff at woodruff@oxy.edu or Professor Shamasunder at Bhavna@oxy.edu. If you have any questions about your rights as subject in this study, you may contact Occidental's Institutional Review Board Office at hsrrc@oxy.edu.

CONSENT STATEMENT:

By clicking "I agree" below you are indicating that you are at least 18 years old, have read and understood this consent form, and agree to participate in this research study. You may wish to print a copy of this page for your records.

1. *

Mark only one oval.

I agree.

I do not agree.

Stop filling out this form.

2. What is your position at Occidental? *

Mark only one oval.

- Student
- Staff
- Faculty
- Administrator

3. How much did your knowledge of sustainability initiatives on campus impact your desire to attend or work at Occidental? *

Mark only one oval.

- Strongly
- Very Much
- Somewhat
- Not Much
- Not at all

4. Do you think Occidental should continue to invest in renewable energy? *

Mark only one oval.

- Yes
- No

5. Which types of renewable energy would you like Occidental to invest in, if any? *

You may select more than one.

Check all that apply.

- I don't know
- Solar
- Wind
- Geothermal
- Hydropower
- Other:

6. What do you think is a reasonable goal for Occidental by 2030, in terms of renewable energy use? *

Mark only one oval.

- I don't know.
- 10-20% renewable energy by 2030.
- 21-30% renewable energy by 2030.
- 31-40% renewable energy by 2030.
- 41-50% renewable energy by 2030.
- More than 50% renewable energy by 2030.