The Real Solar Leaders: American Colleges and Universities

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Executive Summary

Solar energy production has not even begun to fulfill its potential as an abundant energy supply. With total global solar energy providing less than 0.01% of our energy needs there is much room for growth. While there has been government incentive based programs, there has also been a lack of consumer driven leadership in the solar market. Solar energy has not been applied on a mass scale because people are undereducated and misinformed on not only the environmental benefits but the economic advantages and savings of solar energy.

Institutions of higher education have the ability to lead our world in new and expanding fields of opportunity. Colleges and universities are leaders that have the knowledge and capacity to educate mass numbers of people on the most advanced ideas and technologies. I will argue that colleges and universities have the best ability and opportunity to lead our society towards more sustainable energy sources, specifically analyzing solar energy.

Through case studies of successful college solar installations my research will illustrate how institutions of higher education can be successful as the leaders in the field of solar energy. My findings will demonstrate that through a variety of financial options institutions of higher education have the ability to economically finance successful solar projects. I will also prove that the educational opportunities available through constructed solar projects are essential to facilitate growth in the solar industry.

I recommend that more policy incentives for the non-profit and governmental sectors be established to better assist the growth of solar energy. Also, that a renewable energy credits programs be established in every state in America thus assisting those that

install solar and providing them with the best available markets to payoff the initial costs of building a solar project. I will recommend that it is essential for colleges and universities to commit to solar programs in order to further their own growth and responsibility as leaders in our society.

Solar energy is a viable opportunity to support more independent and sustainable energy throughout the world.

Background and History

In order to understand solar energy today it is important to recognize how we got here. The history of photovoltaic (PV) solar energy is much older than we traditionally imagine.

In 1876, William Grylls Adams, along with his student Richard Evans Day, discovered that a solid material known as selenium, produced electricity when exposed to light. In the late 19th century, Auguste Mouchout created the first machine powered by sunlight.[1] This contraption consisted of a steam powered engine that was modified to use the sun as its primary energy source. However, extremely high costs compared to the plentiful availability of fossil fuels at the time made this technology less viable. The American industrial revolution was dominated by the uses of fossil fuels to power the newly built industries. It was not until 1953 that the original dream of solar energy became a reality. That year Gerald Pearson, Daryl Chapin, and Calvin Fuller while researching silicon made a discovery that this material was much more efficient for making a solar cell than previous materials used.[2] They were able to create a solar cell that could produce enough energy to run everyday electrical equipment. Today, we refer to electricity produced directly from light as the photovoltaic (PV) effect.[3] It was not until 1956 that the first photovoltaic (PV) cells were built.

The high cost of generating solar energy kept the new discovery out off commercial markets. At $300 a kilowatt, in the late 1950's, it was much more expensive compared to the $.50 per kilowatt which was the price of electricity that power plants

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[1] "Passive Solar History" John Perlin
[2] ibid
[3] ibid

produced.[4] This expensive solar energy was only used for small toys and radios.[5] After a few years the Army and Air Force saw the potential for solar energy to power the new development of earth-orbiting satellites. While solar satellites had its competitors in the early years, since the late 1960's solar cells have become the accepted power source of satellites.[6] It was not until the early 1970's that solar on Earth could begin to compete with the prices offered by standard electrical producers. Dr, Elliot Berman, with financial backing from Exxon Corporation, was able to lower the cost of production by using more affordable materials so that solar energy could compete in situations where people needed electricity distant from power lines.[7] These types of situations included: lighthouses, off-shore oil rigs, warning lights at railroad crossings and even to pump water in remote parts of sub-Saharan Africa.[8]

In 1973 solar burst onto the scene when the Arab Oil Embargo dramatically increased the prices of crude oil and natural gas; our primary resources for generating electricity in America. The U.S. government took this opportunity to invest heavily in alternative energy sources, one of which was solar energy. The idea and hope was that the high prices of crude oil would allow solar technology to develop and become much more efficient and economically competitive through government subsidies and investment. This vision turned out to be true but America would wait another 20 years.

"Since 1983, half of the households in the outlying islands of Tahiti have relied on solar-generated power. More rural Kenyans use electricity from the sun than that offered by the national utility. At least one hundred thousand families in Mexico, Central

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[4] "Solar Energy History -- Learn Who Discovered Solar Energy"
[5] ibid
[6] "Passive Solar History" John Perlin
[7] "Solar Energy Science Project Topics: History of Solar Energy."
[8] ibid

America and the West Indies run their lights, television sets, and radios with solar electricity."[9] These successes in the less developed world have led the World Energy Council, the international organization of utilities, to recognize, "solar cells for use at individual houses are a very important development that warrants particular attention as they are ideal for low-power rural applications."[10]

PV systems are also part of our developed societies. "Solar generation capacity has progressed from an energy source used mostly for remote power off-grid locations to a viable energy source for those with access to the electricity grid."[11] The smallest systems power calculators and wrist watches. Larger systems provide electricity for water pumps, highway signs, communications equipment, mobile homes, navigation buoys, streetlights, running household appliances and even powering lighting for homes and businesses. However, as of 2008 total solar electricity production still accounts for less than 0.01% of total Global Primary Energy demand.[12]

Technology

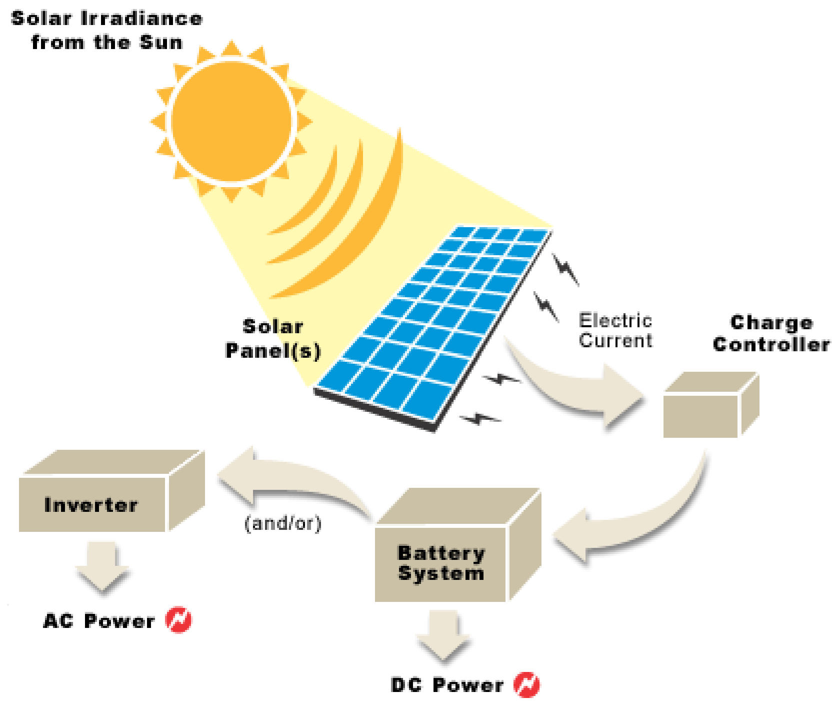
"PV cells are made of a semiconductor material, typically silicon (from beach sand, an abundant resource), which is treated chemically to create a positive charge layer and a negative charge layer. When sunlight strikes a PV cell, an electron is dislodged. These loose electrons are gathered by wires attached to the cell, forming an electrical

[9] "Passive Solar History" John Perlin
[10] ibid
[11] "A Historical Analysis of Investment in Solar Energy Technologies" US Department of Energy
[12] "Fast Solar Energy Industry and Market Facts."

current. The more cells the greater the current and voltage. A number of PV cells laid side-by-side form a rectangular module; several modules together form an array."[13]

Figure 1 illustrates how solar energy is transferred through the photovoltaic system and into actual energy source.

Figure 1: Conversion of Solar Energy



Technology continues to be developed and solar cells are being created to convert a higher percentage of solar energy into usable energy. With each new finding photovoltaic systems become even more competitive.

[13] "Photovoltaics" California Solar Center

Policies and Incentives

Most recently there have been efforts made to develop PV into more mainstream applications. These developments have been made possible through government rebate programs and policies that have directly contributed to furthering the number of installations. The federal government in 2009, as part of the Recovery and Reinvestment Act, established a plan to spend close to $1 billion on renewable energy, of which close to 70% will be spent on solar energy.[14] This money is directly spent on the installation costs of solar energy and had to be applied for by the specific programs. The federal government also has a tax credit program for solar installation. However, these credits are only for existing homes and businesses or new constructions.[15] State governments have also taken initiative in offering rebates to those installing solar energy. One example is California's Solar Initiative, which offers performance based rebates or incentives.[16] These performance based incentives (PBI) refund the owner of the solar system money based on how many kilowatts (kW) of energy are actually produced by the array. Other rebates come from local utilities of water and power. These local rebates can come in the form of performance based incentives but may also cover initial startup costs based on size of the array.[17]

With many incentives available through different levels of government how have we not witnessed dramatic increases in solar energy production? The truth is that even though government programs have been established to further the growth of the solar industry, there has not been a leader on the consumer side of the industry. This leader, or

[14] "Photovoltaics" California Solar Center
[15] "Federal Tax Credits for Energy Efficiency : ENERGY STAR."
[16] "California Solar Initiative-PV Incentives."
[17] ibid

driving force would create a market for solar and help further facilitate growth in the overall industry.

Perspective

Institutions of higher education: the innovators of our society, home to the best and brightest of the new generation, and leaders in the wave of new technology. Solar energy: potentially a leader in sustainable energy, the innovation that will draw us away from foreign oil dependencies, the wave of the future. So where then do these two intersect, if at all?

Colleges choose to lead in many of different ways; one being the resources they invest in programs that are untested or not fully understood. These are risks that colleges can and do take everyday in order to achieve their quest of becoming more highly acclaimed and attract even better students. Colleges have the unique advantage in that they have no real failures. Instead, colleges take each lesson as a learning tool for the next project or process. These educational steps may take years or decades, but once again colleges have the advantage of time because they are institutions so ingrained into our society that they are and will forever be present. Each year new students come to learn at these places of higher education and each year these colleges take new risks in order to not only teach the new but to learn about the opportunities available.

"Universities posses access to the most up-to-date knowledge of both environmental problems and technical solutions, they have the responsibility to lead society towards environmentally sustainable policies and practices."[18] The major breakthroughs in solar PV technologies have come from universities including the most recent technological advancements made at Caltech in March of 2010.[19] Evidence for climate change also comes from research and analysis done at universities throughout the nation and world. This being said, colleges and universities continue to heavily rely on fossil fuels for the energy needs.[20] What does this mean? Colleges and university have all the information on climate change and solar technology but they have not applied it to their own institutions. It is absolutely imperative for universities to apply their findings when capable in order to continue growth as the leaders of our society. By not using the resources at hand universities are contradicting their own studies and philosophies.

Solar energy appears to be an obvious solution, being an extremely abundant energy source that can provide real local solutions to an energy crisis that is only beginning. Energy that is so clean, reliable, and plentiful how could our society not capitalize on it? We, Americans, the inventors of the telephone, airplane, and Colt revolver, we must be the leaders in the field of energy, right? Wrong. Dependence on foreign oil, something over talked and published by so many brilliant people in our society. From local environmentalist to President Barack Obama, we hear the words "sustainability" and "renewable-energy." What are these words without the concrete plans to reform our ways of life. We now have federal money pouring in to our communities all across the nation, with a portion allocated for solar development. So why did it take a federal program to incentivize solar energy? Where were our

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[18] "Catalyzing Mass Production of Solar Photovoltaic Cells Using University Driven Green Purchasing." Pearce

[19] "Caltech Researchers Create Highly Absorbing, Flexible Solar Cells with Silicon Wire Arrays."

[20] "Catalyzing Mass Production of Solar Photovoltaic Cells Using University Driven Green Purchasing." Pearce

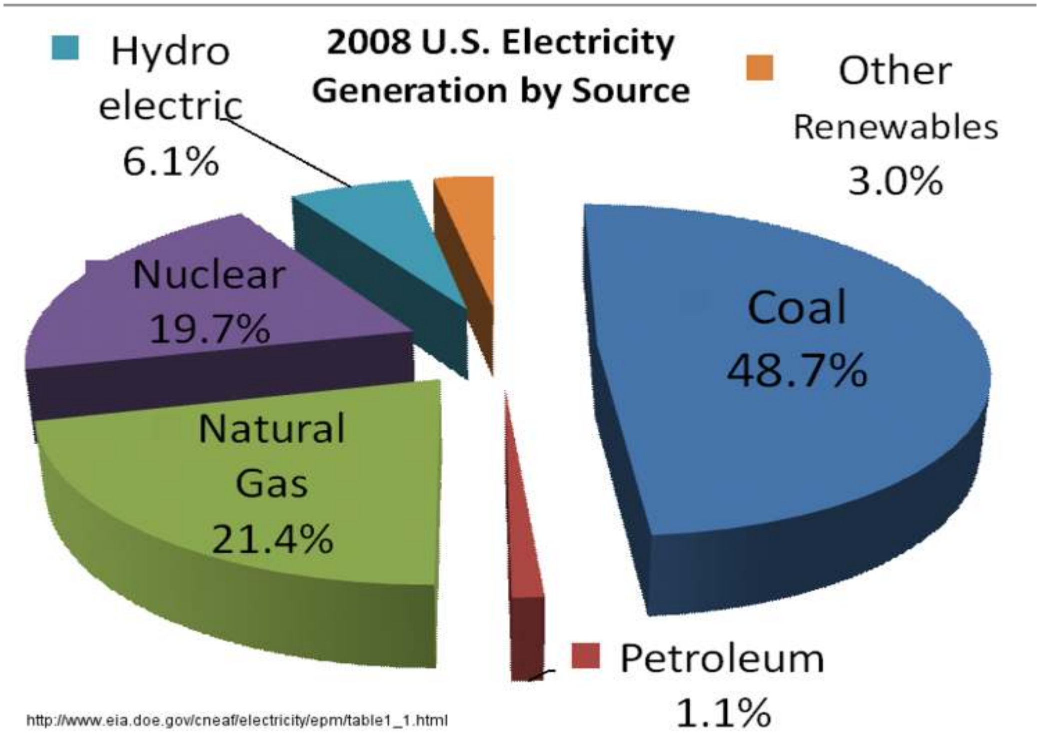
innovators, our leaders, our future? The fact is that colleges did not take the initiative and did not capitalize on the opportunity that is solar energy. In short, there was much talk with very little action.

Not to say that there were not any innovators out there in the Pre-Stimulus Era, but why not the demand for sustainable energy. At a time when crude oil prices, coinciding with real gas prices at the pump, were escalating once again. When the public blatantly knew the intentions for our military presence in the Middle East. All the research and knowledge about how global climate change is real. (See NASA research http://climate.nasa.gov/). However, people have the notion that more fuel efficient cars can save us from our dependence on foreign oil. This is a myth. Our countries use of cars grows at a faster rate than the rate at which we advance in fuel efficient technology. Simply put, the advancements of fuel efficiency in cars will not save us from oil dependence as more people continue to drive even more. (For more information: Urban Land Institute)[21]

So if we are not making real and quantitative progress in the transportation realm then we must focus our efforts on the other real consumers of fossil fuels. One thing that people can easily understand is that automobiles burn fossil fuels. You go to the gas pump, you put gas in your car, and after you have driven a certain number of miles you have to go back to fill up your tank with more fossil fuels. You can easily understand that you are burning gasoline by driving your car. However, when you switch on a light in your American home there is an 71% chance that the energy needed to power that light bulb is coming from the burning of fossils fuels (see figure 2).

[21] "Growing Cooler: the evidence on urban development and climate change"

Figure 2: U.S. Electricity Generation by Source[22]



It is much harder to educate people on that fact because they can not visibly see the burning of fossil fuels. They do not have to go out and fill up their gas tank in order to keep powering the electricity in their home or office. In reality that is exactly what is powering our electrical energy uses, it is the burning of fossil fuels and we are doing very little about changing that. Figure 2 illustrates the percentage of fossil fuels used compared to that of renewable energy sources. The "Other" category listed includes solar energy and in total it only accounted for 3% of total electricity generation in 2008. While we focus so much of our efforts on changing the fuel efficiencies of cars we actually miss

[22] "Electric Power Monthly - Table 1.1. Net Generation by Energy Source."

out on the greatest emitters of all. “Power plants account for 40 percent of U.S. greenhouse gas emissions and 25 percent of the world's.”[23]

The question is why do people not care about this? Is it pure ignorance? If people really had cared they would have sought the answers to these questions. Maybe we have taken a “don’t ask don’t tell” type of approach to this situation. We have been caught in an era in which we would rather debate with the other half of the aisle rather than take the real important time to find concrete solutions to our problems. These problems are things we created and are here to stay.

So our solutions must come from those willing to invest time, efforts, and resources in something that may pay no real monetary reward in the immediate. Our average citizens have not taken the idea of climate change seriously enough and neither have our politicians. The lack of real and concrete policies still inhibits the competitiveness of renewable energies in the open market. Solar can not yet compete with the standard industries of natural gas, oil, and coal. The advantage renewable technologies have is that, their resources are abundant and endless, something fossil fuels can no longer say.[24] We once believed that fossil fuels would supply our energy needs forever but experts now agree that this is completely false and that the amount of fossil fuels is diminishing faster than originally expected.[25] So what are we to do; keep our current system so that we may continue on the path of unreliable consumption of a resource that is in fact not everlasting?

Now America has the stimulus package about to flood the markets and more solar energy initiatives in fine print than one would like to count. The fact is that even with the

[23] "World's Power Plant Emissions Detailed"
[24] "Executive Summary (Table ES-1) - DDS-60." *USGS*
[25] ibid

stimulus money we will have only begun to take the necessary steps towards renewable energy. This government lead initiative towards renewable energy shows leadership and vision on part of the current administration but it will not solve our answers in the long term. More programs, more education, and more solutions are needed to solve are energy crisis.

So where to we go from here? Where can and should America go with the field of solar energy? These are questions being asked by many of different institutions of higher education.

Research Questions

How can colleges and universities increase their role in the development of solar energy by implementing successful solar energy projects on their campuses? How can institutions of higher education become leaders in the world of renewable energy?

Subsequent questions: What are the best and most reliable financial options for colleges and universities to install solar? What types of programs and student involvement are necessary for educational outreach around solar energy?

Methodology

I will be using information collected from my case studies of colleges and universities in order to answer my research questions. These case studies come from colleges that have already built solar arrays and those currently in the process of doing so. In order to answer my questions I have gathered information through interviews with individuals closely related to solar arrays on their respective campuses. Information was also gathered from previously published records on the details of specific projects.

Literature Review

In this section I discuss the literature that will be used as background in shaping my argument for solar energy and institutions of higher education. There is extensive literature written on the areas of renewable energy sources and the potential benefits for businesses and residences converting to these energies. There are studies on the policy application of solar energy. However, there is a significant break in literature on the ability and role that institutions of higher education play in the world of solar energy. Because corporations and government programs have been the driving force for solar energy and not consumers, the current published literature is only able to review the cases of such businesses and their practices. Other literature responds to the residential opportunities of solar energy. Education has played a certain factor in the ability for all consumers, colleges included, to understand the economical savings that are achieved through switching to solar energy. The lack of community participation in energy choices and renewable energy projects is reflected in the business dominated solar industry.

The literature that is currently available does not present a clear plan to how or who has the ability to change the energy infrastructure of our society to one that is renewable based.

During the time period of 2001 to 2004 the U.S. Department of Energy Solar Energy Technologies Program accounted for an average of 50% of the total investment in the U.S. solar sector.[26] This government involvement soon disappeared as the business sector realized the profit potential of the solar industry. From 2004 to 2007 the U.S. solar industry increased from $215 million annually to almost $3.2 billion, with government investment accounting for a mere 4% of total solar investments.[27] This dramatic shift towards non-governmental investments can be attributed to the economic incentives given by governmental policies. Policies and programs make solar energy economically feasible for business investment but are focused on the business and residential sectors of the market for solar energy.

The National Laboratory of the U.S. Department of Energy released a report in 2007 that laid out the barriers to solar energy use. This report used more than 19 academic sources in coming up with the conclusions that solar energy actually lacks true support from government policies.[28] The lack of financial support on behalf of governments is compounded with the ever changing policies on renewable energies by government agencies. Because of this there is a regulatory risk that consumers take when installing renewable energies as the prices can vary dramatically due to changing government policies.[29] Studies done on the evolution of solar policies choose to focus primarily on commercial and residential funding for projects, with neither of the two really standing out as the driving force for this industry.

The residential sector faces numerous barriers in attempting to convert to solar energy. A study done in both the UK and U.S. called, "Green Electricity in the Market Place: The Policy Challenge," came up with conclusions to the barriers consumers have

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[26] "Historical Analysis of U.S. Investment in Solar Energy," US Department of Energy
[27] "A Historical Analysis of U.S. Investment in Solar Energy"
[28] "Nontechnical Barriers to Solar Energy Use: Review of Recent Literature"
[29] "UK Innovation Systems for New and Renewable Energy Technologies: Drivers, Barriers and Systems Failures"

faced. The first being, consumers have been locked-in to conventional electricity consumption patterns in which there are no need to make choices on an electricity provider.[30] Secondly, there has been a lack of consumer knowledge about electricity supply options as well as their own electricity consumption and the environmental consequences.[31] These along with other factors have left consumers in the dark about the possibilities of renewable energy. There has been no consensus as to why consumers have not led a more proactive role in controlling their energy supplies. One hypothesis is that consumers have considered choices about environmental impacts of electricity as the responsibility of the provider.[32] If this is true, then all the protests and complaints about the impacts our society is having on global warming are action less.

Consumers are interested in solar energy and they do expect government and private firms to invest resources into the research and application of solar energy.[33] Surveys conducted in a study by the Solar Electric Power Association in 2002 found that 70% of people believed, "developing renewable energy should be a higher priority than building more fossil-fuel plants." This study also provides facts that consumers are misinformed on the source of their energy supplies. Consumers are also uneducated on the environmental impacts on electrical energy use, stating that, "air pollution caused by electricity generation is relatively small compared to other sources."[34] This misinformation on the part of consumers is found throughout literature and research on understanding the social dynamics of renewable energy.

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[30] "Green Electricity in the Market Place: The Policy Challenge"
[31] ibid
[32] ibid
[33] "Solar Power Solutions: A Business Case for Capturing Total Value"
[34] Solar monkey, http://www.solarmonkey.net/privacy.php

A financial situation that comes up often throughout literature mostly published by solar energy companies, involves a system known as Power Purchase Agreement (PPA). These agreements rely on the ability for companies to design, install, finance, and maintain the solar array. The PPA systems are advertised by solar companies as the most, "economically feasible" and "cost effective" way of installing solar.[35] PPA's are presented as a feasible way for non-residential markets to build solar arrays. PPA's were first introduced by SunEdison in 2003. Since that time PPA's have grown to roughly 50% of the total market, as of 2007.[36] This market expansion has given the PPA much publicity and has enticed more companies to now use these. However PPA's are said to be vulnerable for a number of reasons.

Declining levels of incentives in the larger markets of the Unites States, including California, are going to make it tougher for third party companies to finance solar systems.[37] According to the Lawrence Berkeley National Laboratory, credit quality will also contribute to the opportunities of PPA's. Since contracts for PPA's usually last 15-20 years, the third party companies need to keep their tax equity investors who have financed PPA's but are now reconsidering due to the dire economic times.[38]

Other financial options for non-residential consumers include balance sheet financing. This was the first type of financing and it continues on today. In this model the host site, also known as the consumer, fully finances the solar project and will hire a third party to develop and build the solar project. The financing for these types of projects varies dramatically. Often, debt is assumed by the host site in the idea that the

[35] ibid
[36] "Financing Non-Residential Photovoltaic Projects: Options and Implications."
[37] ibid
[38] ibid

solar array will save money in the long term. Tax incentives along with bonds and rebates are used to help finance an initial portion of the project. This helps to lessen the burden of financial debt.

Leasing is another possibility for non-residential users. In this scenario a third party builds a solar array and then leases the entire built project to the host site. The host site is then responsible for the maintenance and operation of the project, but is also entitled to the energy supplied by the structure. This creates financial stability for the host site because as long as the lease is fixed so is the price of energy produced by the array.

There are two types of leases. One in which the lessee intends to make payments on the project and in turn is expected to own the array at the end of the leasing agreement. The other type of lease is one in which the lessee will not own the project at the end of their lease. These are the basics of the different leases but there are many other legal alternatives to as what and who can and will own, operate, and maintain the solar array.

The research misses on the opportunity to explain the specific ways in which other sectors can and have specifically financed solar projects. My research will give concrete examples and explanations to how institutions of higher educations can propose, finance, and construct solar projects. I will also detail how certain obstacles can be avoided and overcome.

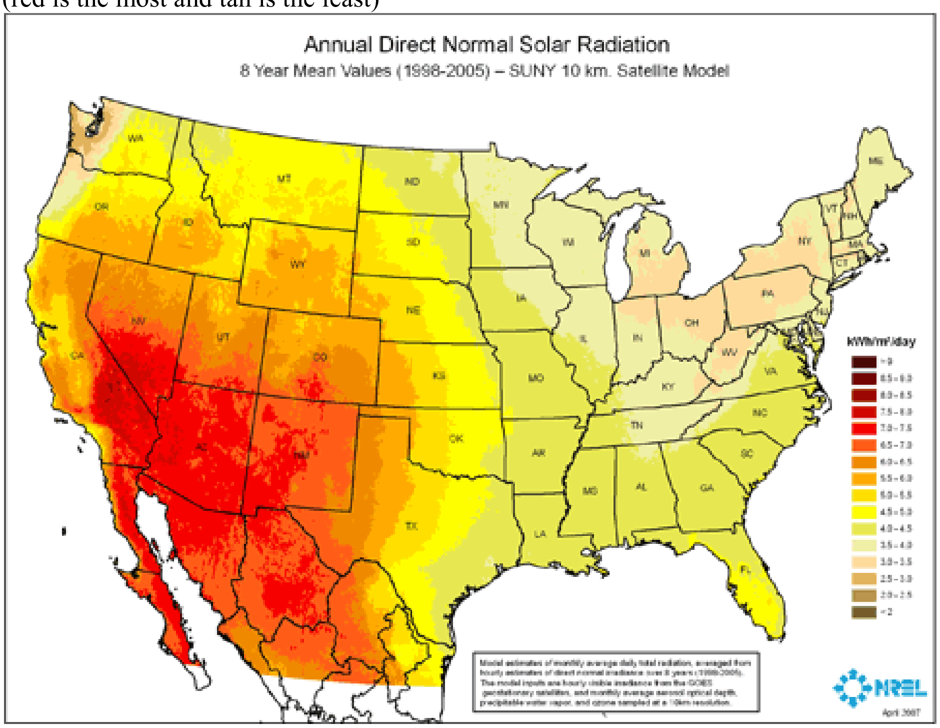
Clarifications

For the purpose of this study I will be concentrating my research exclusively on the effects of photovoltaic solar energy. This type of technology uses solar cells to directly convert sunlight into an electric current. While thermal solar heating and other viable solar opportunities are important, photovoltaic energy can be used more universally for energy needs. Also, 100 Kilowatts (kW) are the equivalent of 1 megawatts (MW).

Occidental College

One of the reason I have chosen to research the process of solar installation on college campuses is to best understand how my own college can learn from other examples and understand the process, planning and implementation of our own project. Occidental is located in Los Angeles, California and as with a number of my case studies Occidental is located in a region with an abundant amount of sun. (See Figure 3)

Figure 3: Annual Direct Normal Solar Radiation
(red is the most and tan is the least)[39]



[39] http://www.nrel.gov/csp/troughnet/images/map_normal_radiation.gif

Plans for solar installation are relatively new to a campus that has the potential for great amounts of solar energy. Occidental is like most colleges in that they receive their electricity from the local utility provider. The power supplied to colleges, including Occidental, is no different than that of other sectors. And since 70% electrical power comes from the burning of fossil fuels (see Figure 2) then colleges are just as responsible for greenhouse emissions from power plants.

Research

In order to combat Occidental's dependence on power plants and thus fossil fuels, professor Dan Snowden-Ifft took it upon himself to research the possibilities of solar energy on campus. Occidental College has a sustainability committee comprised of both faculty members and students. In May of 2009 this committee, with the help of Dan Snowden-Ifft, established a solar subcommittee with the purpose of researching the possibilities of solar energy on campus.[40] Dan Snowden-Ifft and this committee helped to draft the first plans for a solar array at Occidental College.

Snowden-Ifft's findings showed that the best availability for solar panels was not on the roofs of buildings, as with most urban colleges, but rather on the available land located above the developed portion of campus. His research showed that the buildings were not conducive to solar panels because of their older and historical nature. The buildings would have had to been retrofitted in order to sustain the additional weight of solar panels.[41] Also, with the lack of a single concentrated building rooftop, the solar energy would have had to been transmitted from multiple solar locations. The effects of

[40] Interview Dan Snowden-Ifft
[41] ibid

transporting the energy from multiple locations results in the loss of electrical power.[42] (See Boltzmann Transport Equation for more information)

Proposals

The original proposal of a 2 megawatt solar array was made to Occidental College Board of Trustees during the summer of 2009. Because Occidental is located within the Los Angeles Department of Water and Power(LADWP) service area, which prohibits the use of power purchase agreements(PPA), Occidental had to strategize a way to self fund a portion of the project. Although almost half the cost of the array would be covered through rebates offered by LADWP, funding for the project was a major barrier for the Board of Trustees.[43] In order to self finance this project the Board of Trustees wanted to be assured that this was an economically sound investment. The original plans were requested to be revised and professor Snowden-Ifft and others had to construct new plans.

During the fall of 2009 more proposal were put forth and once again more issues were raised. One major problem was the aesthetic appeal of the open space currently located above the campus. Although the solar array would only cover a fraction of the hillside administrators of the college still worried over the community backlash of building upon one of the very few open spaces in the local vicinity. In order to appease the opposition, a specific design was created so that, "the project did not look militarized."[44] This new design has a natural flow with the landscape and should blend in much more than the previous designs. (See Figure 4) This new design was the first of its

[42] "Boltzmann Transport Equation" Lachish
[43] Interview Dan Snowden-Ifft
[44] ibid

kind and was a work in collaboration with the LETTUCE, an architecture firm based in Los Angeles.[45]

Figure 4: Occidental College Proposed Solar Array

Students for Solar

Along with the new design in the Spring of 2010 there was also student support for the solar array. As part of the student political body there was a Student Solar Committee formed to help build support for the proposed solar array. Derek Singleton and I founded the committee through Occidental's General Assembly in order to bring awareness of the proposed solar project to students. After speaking with and educating hundreds of the students on our campus, Derek and I along with Charlotte Krovoza started a solar petition. The purpose of the petition was to demonstrate the student

[45] Interview Dan Snowden Ifft

support for solar on campus. More than 20% of the student body signed the petition in support of the newly proposed 1.14 megawatt system. Along with the Student Solar Committee the Associated Student of Occidental College passed a resolution that they would support plans for a solar array on campus (See Appendix).

Along with student support there was also support from faculty and Jonathan Veitch, the President of Occidental. The offices of Urban & Environmental Policy and Physics were two of the leaders in founding the proposals and pressuring administrators to devise a plan that would be financially accepted by the Board of Trustee.

Case Studies

Case studies are the primary research done on how specific colleges and universities have built solar arrays on their campuses. There will be detailed information on the history and successes of specific solar projects. The studies will describe obstacles and lessons learned. These individual colleges and universities were chosen because they represent a wide variety of option for solar arrays. The schools chosen are part of a very limited group of colleges that have installed solar projects on campus. In all, only ten colleges have planned or completed more than 1 megawatt of solar energy and of those I will be discussing three of them.[46] The case study on LMU is important because at the time of completion it was the largest project and is still one of the top 15 in terms of energy production.[47] The last case study at San Diego State is the most unique in the country in that it is the largest completed solar array that was planned and financed by the

[46] *Sustainability in Higher Education,* AASHE
[47] ibid

students of the college. The different example will be used to best illustrate the best ways in which other colleges have install solar energy.

Arizona State University

History

Arizona State University (ASU) has and continues to be at the forefront of solar innovation. Starting in 1954, the Association for Applied Solar Energy (AFASE) established its headquarters in Phoenix, Arizona.[48] The research center worked closely with ASU professors and researchers. The research and technological advancements of solar energy would drastically change during the 10 years that the AFASE was located in Phoenix.[49] In 1981, as an outgrowth of ASU research projects, the ASU Solar Research House was built to help "train a generation of solar professionals."[50] This facility was used as an experiment to test the different models and designs of solar products at the time.

In 1992 the university established the country's first Photovoltaic Testing Laboratory located on their Polytechnic campus.[51] This laboratory was one of only three in the entire world and helped solidify ASU as one the world leaders in solar energy.[52] The university has since developed the laboratory beyond just a research institution. Outreach and education programs for both ASU students and the community were

[48] "The Association for Applied Solar Energy/Solar Energy Society, 1954-1970."
[49] ibid
[50] "ASU Research Sets Stage for ?green? Growth in Arizona."
[51] ibid
[52] ibid

created and have become a vital piece to their mission statement.[53] Also, included in their mission statement is to provide a focal point for prototype and system analysis for renewable energy sources. These programs along with others have continued to establish ASU as a leader, innovator, and educator in the field of solar energy.

In the 2000's ASU continued its commitment to renewable energy as it established a purely solar power laboratory, designated specifically to solar design and research.[54] The success of each project has led to the continual development of educationally bound solar projects. No real construction of solar panels for energy use was established until 2004. The Global Institute of Sustainability was launched the same year and as its first project it helped to design and build the first permanent solar project on the university campus.[55]

Projects

The Tyler Street Parking Structure Project was the first permanent solar array on ASU's campus. This project, which is currently in use, supplies 30 kilowatts of solar energy.[56] The energy is specifically used to operate the daytime lighting and electrical uses of the parking structure.[57] The solar structure was built on the roof of the parking structure and shades about 44 automobile spaces, acting as a carport. The funding from the project came solely from the university and therefore the university owns the entire solar project outright.[58]

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[53] "ASU Research Sets Stage for ?green? Growth in Arizona."
[54] "Arizona State University Creates Solar Power Laboratory."
[55] "Arizona State University Project " *Solarplaza*
[56] ibid
[57] ibid
[58] "Arizona State University Project " *Solarplaza*

During the spring of 2006, three students led by professor Harvey Bryan studied the rooftops of all buildings located on the Tempe campus of ASU. They found that 25 of the building rooftops were suitable for some type of photovoltaic solar project and estimated that there was potential for more than four megawatts of solar energy on the designated rooftops.[59] Following this study, the university conducted its own assessment and found that there held the potential for an additional 3-5 megawatts of rooftop space for solar energy.[60] This led to the development of a master plan to install solar energy on a mass scale across the Tempe campus of ASU. This student-professor led research group ultimately helped to form the solar initiatives and projects that have been constructed since that time.

In January of 2008, ASU took the initiative to research the best plausible ways to fund a major solar project. Due to the planning commitment of the college to continue its leadership role in sustainable energy the college was able to agree upon plans to install solar for the year 2008.[61] ASU then issued a request for proposal (RFP).[62] Meaning that they wanted to test the market and evaluate the price of installing a major solar project on campus through a private company. The university calculated that the best financing option was to hire a private firm to install, own, and operate the project. Then, to have an agreement that the private company sell ASU the electricity generated from the solar project at a flat rate. Legally this is known as a Purchase Power Agreement or Quality

[59] ibid
[60] ibid
[61] Interview Bonnie Benson
[62] "Arizona State University Project " *Solarplaza*

Management Agreement and was solidified by a 15 year contract that has buyout options at the end of the period.[63]

Three companies were selected for construction of the solar projects. ASU committed to building solar energy and divided the projects into three different phases. The first of which was to be completed by the end of 2008.[64] The university successfully installed all of the phase 1 projects by April of 2009, creating a total of 1.8 megawatts of solar energy.[65] This energy came in way of four projects seemingly separate but part of the master plan. The buildings chosen for the project were parking lots that could handle the weight of the solar arrays or if they could not handle the weight they chose rooftops that needed renovation and as part of the refurbishment were built to sustain the weight of solar panels.[66]

The first project completed was located on the Stadium Parking Structure and generated 711 kilowatts. The next project was built on the Apache Blvd. Parking Structure and generated 880 kilowatts of energy. The last of the project to be completed was the Lattie Coor Building with 108 kilowatts. These three projects were different from the fourth in that they were funded through a PPA and are now currently owned by Sun Devil Solar.[67] The fourth of the projects constructed from 2007 to 2009 was built on the roof of Bio Design A and B.[68] This structure which generates 150kw, is owned and operated by ASU.[69]

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[63] Interview Bonnie Benson
[64] Interview Bonnie Benson
[65] "Campus Solarization Status" Brixon
[66] Interview Bonnie Benson
[67] "Campus Solarization Status" Brixon
[68] "Arizona State University Project " *Solarplaza*
[69] "Campus Solarization Status" Brixon

Since the completion of phase 1 ASU has moved on to phase 2 of the process in which they are to complete an addition 8 megawatts of solar energy by the end of 2010. According to the University Sustainability Practice Director, Bonnie Benson, the projects in phase 2 are on pace for completion by the end on 2010. This will put ASU at a total of 10 megawatts of solar energy, exceeding all other national colleges and universities.[70]

Financing

Many financial options were considered following the Tyler Street Parking project. Due to state legal restrictions the university was unable to build more upon their existing buildings.[71] Because of this they discovered that if another company built and operated solar project that the addition to the building could not be restricted. The Quality Management Agreement was reached to insure that a third party company was operating the additional construction of the building.[72]

In order to maximize price efficiency, "The pricing takes advantage of federal and state tax credits, as well as incentive payments provided by Arizona Public Service as authorized by the Arizona Corporation Commission's Renewable Energy Standard Ruling." [73] These tax credits that the installation company receives for building the solar array translates into even lower costs of electricity for ASU because the company has less financial paybacks on the array. Future projects by ASU will also be financed through the Quality Management Agreements. (See Figure 5)

[70] "Solar Panels on Campus | Association for the Advancement of Sustainability in Higher Education (AASHE)."
[71] Bonnie Benson Interview
[72] ibid
[73] "ASU to Deploy Largest University Solar Installation." Leland

Figure 5: Arizona State University Projects

2009/2010. Phase II Projects Planned for Fiscal Year 2009/2010

Location	Ownership	Estimated Size	Output Cost (2)	Status	Estimated Completion
Tempe Campus:					
Parking Structure #4	APSES	296 kW	.122/kWh	In contract negotiations	4/2010
Parking Structure #7	APSES	290 kW	.122/kWh	In contract negotiations	4/2010
Parking Structure #3	IEG	215 kW	.1489/kWh	In design	3/2010
GIOS	IEG	24 kW	.1489/kWh	In installation	12/2009
Hassayampa Academic Village	IEG	138 kW	.1489/kWh	In design	12/2009
Hayden Library	APSES	290 kW	.122/kWh	In contract negotiations	4/2010
Student Services Building	APSES	185 kW	.122/kWh	In contract negotiations	4/2010
Farmer	IEG	111 kW	.1489/kWh	In design	3/2010
Macro Technology Works	APSES	189 kW	.122/kWh	In contract negotiations	4/2010
Noble Science	IEG	108 kW	.1489/kWh	In design	4/2010

http://asu.edu/fm/documents/oua/campus_solarization_2009_09.pdf

Community Response

After the first project was built there was a large response by many within the ASU community. "Students felt that the solar array was not visible enough and that the university was over exaggerating their commitment to sustainability and solar energy."[74] This response continued through until the projects in 2008 which were made much more visible by the school. The school took into consideration the complaints of the students but also had to balance the possible loss of efficiency. The university also built

[74] Interview Bonnie Benson

monitoring stations on the ground level so all persons may be able to visibly see the amount of energy being collected by the solar arrays.[75] Bonnie explained that in her experience students actually walk routes in which they intentionally pass these stations in order to read the tracking machines.

The most recent student response to solar projects has come in the wake of recent tuition increases. Students are now complaining that these projects are directly affecting their tuition costs.[76] However, these allegations are false as the PPA type of solar installation actually costs the school nothing and they actually save money by purchasing electricity at a lower rate than before. The complaints come as some students are not educated on the logistics of the solar projects.

The university has also taken into consideration the effects that the solar projects have on the students, professors and other facilities. In one example a solar roof top project was struck down because the top floor of the building was a music studio and construction of the solar array would have potentially disrupted the ability for the music studio to operate.[77] This represents ASU's commitment to keeping the interests of its students first.

Educational Opportunities

A campus metabolism project is in the process of being built to educate people of the greater community on many different aspects of solar energy and the solar project on campus.[78] The education outreach will provide children of the community with the

[75] Interview Bonnie Benson
[76] ibid
[77] ibid
[78] ibid

opportunity to learn about sustainable practices. Beyond children, this project will detail aspects like the different types of solar panels used on campus, which amount to 10.[79] ASU has committed to outreach programs in order to further the understandings of the capability that solar energy has. This type of leadership is an excellent model for how institutions of higher education can become leaders in solar energy.

California Institute of Technology

Background

California Technology Institute known better as Caltech, is a nationally recognized institution of research and technological advancement. Their mission commits to the development of the sciences and technology.[80] Within the realm of technology Caltech has developed alternative sources of energy to supply the university. In 2003, the college installed a Combined Cycle Cogeneration machine that runs on natural gas. As of 2007 this machine produced 74% of the energy used by Caltech while reducing CO_2 emissions by 17.4%.[81] The total output of energy from this project is 12.5 megawatts.[82] This was the first step in a process by Caltech to develop new ways in which they produce energy. Since the completion of the Combined Cycle Cogeneration project Caltech has been working vigorously on implementing other methods of energy production.

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[79] Interview Bonnie Benson
[80] "Caltech: At a Glance." *California Institute of Technology*
[81] "Combined Cycle Cogeneration - Caltech Sustainability at Caltech."
[82] "Combined Cycle Cogeneration - Caltech Sustainability at Caltech."

Financing

Starting in 2006 the college began investigating solar options.[83] Caltech chose to use a power purchase agreement because, "it required no capital expenditure from the school."[84] The decisions to use a PPA and therefore buy the solar energy from a third party company, was chosen even though Caltech has the funding capability of building an array of this size.[85] Caltech also received a performance based incentive (PBI) from Pasadena Water and Power. This rebate will return $0.632 per kilowatt hour produced by solar energy.[86] The incentive is purely based on the production of the array and will be paid annually for the next five years.[87]

Because of the PPA agreement, Solar Power Partners, the financers of the array, were able to use federal tax rebates to assist in the financing. Since Caltech is a non-profit organization they were not eligible for federal rebates, and this in another reason they chose to use a PPA to finance the project. The rebates offered by the city of Pasadena, the federal tax rebates, and the lower cost of solar energy together are predicted to save Caltech $13 million over the term of the power purchase agreement, which is 15 years.[88] These savings are made possible by the commitment of Caltech to solar as well as the different levels of government and their leadership to provide rebates for solar energy. Solar energy provides the college with lower and more stable energy costs.

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83 "California Institute of Technology." *Solar Power Partners*.
84 ibid
85 Caltech Surpasses $1.4 Billion Campaign Goal." Perry
86 "Caltech Solar Project Receives City Rebate." Weiner
87 ibid
88 "California Institute of Technology." *Solar Power Partners*

Application

The first phase of solar installation took place on the Hollister Parking Garage and was completed by December of 2008. This project alone produces 238 kW of energy.[89] Since the completion of the project there has been a website established to monitor the "real time" tracking of the project.[90] It is an interactive website that visibly shows the amount of energy being collected and compares the energy savings in terms of dollars saved, fossil fuel saved, and other various types of energy users. This is a great way for people to interact with the project and to better understand the capabilities of solar energy. This is an excellent example of how Caltech is able to educate people and promote the growth of solar technology.

The other projects associated with the PPA agreements are under construction and are expected to be completed by the end of 2010.[91] These projects when finished will be found on a number of buildings and parking lots across the Caltech campus and will provide the school with 1.2 MW of solar energy.[92] This will further help Caltech in converting their campus to on-site energy providers.

Concerns

One concern that was brought to Caltech administrators was the possible removal of trees for the purpose of building the solar arrays.[93] Even though the arrays are being built on the roof tops of buildings and parking garages, some of the tree's canopies stretch to cover the arrays and potentially block them from receiving their maximum

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[89] "California Institute of Technology." *Solar Power Partners*
[90] "California Institute of Technology - Building Dashboard® | Lucid Design Group."
[91] Interview John Onderdonk
[92] ibid
[93] ibid

solar energy collection. In order to deal with this problem the college took it upon themselves to replant the net loss of tees in other locations across their campus.[94] Along with this, they have decided to replant trees that are native to the area and are more drought resistant than the ones being removed.[95]

Other opposition came from neighbors that were concerned with the aesthetic look of the proposed solar array.[96] The neighbors were educated on the benefits of the array and informed that the array would not be a hindrance to the aesthetic appeal of the parking garages or buildings. Residents have since come to understand the benefits and there have been no recorded complaints since completion.[97] Another obstacle came in the ability to find an applicable rooftop to build solar arrays. Many of the buildings at Caltech use the rooftops for other projects and functions and since equipment has already been built on them it was difficult to identify those buildings that could be used for solar.[98] Caltech was able to site the solar arrays on locations in which they did not disturb any other function of the building or projects within the building.

Students for Solar

A much different solar project has also taken place on the Caltech campus. This one comes in the form of student leadership and efforts to provide their college with adequate alternative energy. The Caltech Student Solar Initiative started a solar project in the fall of 2009 in order to prove that although the college is producing large-scale energy projects on-campus, the students have not lost their willingness to make a difference as

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[94] "Solar Power Production at Caltech." pg.9
[95] "Solar Power Production at Caltech." pg.9
[96] Interview John Onderdonk
[97] ibid
[98] ibid

well. From November 19th -21st more than 80 students gathered to install the first student affiliated solar project on campus.[99] The total cost of the project for materials and installation was $118,000.[100] Through performance based incentives half of the total cost will be repaid by Pasadena Water and Power. Some of the other costs will be covered through donations, while Caltech's Department of Facilities will incur all other costs.

This array is expected to produce 23,000 kilowatts hours of energy per year.[101] Converted this array is considered to be a 14 kilowatt array. While the actual energy output from the project is relatively small it does much more beyond just producing energy. This program has brought people, particularly students, closer to their sources of energy and understanding the impact that these types of projects can and do have on their lives. Student led initiatives prove as an example of how people can be empowered to make a difference in the world of energy.

Loyola Marymount University

Project

In 2003 Loyola-Marymount College, located in Westchester, Los Angeles, installed the largest solar roof project on any university in the world at the time.[102] The total cost of the project was $4.3 million but through a number of incentives and rebates the project was made much more affordable. The first rebate came by way of the Los

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[99] "Students Go Solar." *Engineering & Science*.
[100] ibid
[101] ibid
[102] "Green LMU Facts and Figures."

Angeles Department of Water and Power that in partnership with the university offset an initial $3.7 million.[103] Next, the Southern California Gas Company subsidized the project by $325,000.[104] The actual upfront cost to the university was only $325,000 and established LMU as a leader in solar energy.

Construction was done on three of the largest buildings located on the campus. Just over 800 kilowatts of solar energy is now being generated from the entire project. Estimates originally figured saving costs would amount to around $150,000 a year.[105] LMU has also found additional benefits coming in the form of, "thermal insulation and protection of the roof from weather and UV radiation, resulting in decreased heating and cooling energy costs and extended roof life."[106] This contributes to the saving costs for the university. At the time of construction this project was viewed as a viable example of how partnerships between universities and utility departments could lead to renewable energy projects.

LADWP Incentives

The LADWP incentive program provided great opportunity for installation of solar projects and LMU took full advantage of these incentives offered. Since that time, rebates have reduced dramatically as the Los Angeles solar market has noticeably growth over the years. By July 1, 2006 more than $85 million had been paid in solar rebates by LADWP to fund more than 600 projects.[107] The LADWP rebates program was established to give its customers the opportunity to invest in clean and renewable energy.

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[103] "JAN 08 03-1 SOLAR INSTALLATION PR" *Loyola Marymount University*.
[104] ibid
[105] "Solar Programs" *Loyola Marymount University*
[106] Green LMU"
[107] "General Content Table of Contents." *LADWP*.

The rebate program was established in 2000 to fund $150 million in rebates through June of 2011.[108] In 2007, the program was extended to run through 2016 in hopes of funding enough solar projects to provide the city with 20% of its total electrical needs.[109]

While the opportunities available through utility companies are important they can not be fully achieved unless customers are willing to invest in the project. LMU took the initiative to capitalize on the rebates offered but more importantly promoted solar energy as a reliable source of energy. This promotion helped to further the rebate program offered by the LADWP.

Rutgers University

In 2009 Rutgers University installed a 1.4 megawatt system of solar energy in an open space next to the campus.[110] Through a Renewable Energy Credits (REC) program in the state of New Jersey they have been able to drastically reduce their total costs of their project.[111] Along with the REC program Rutgers will receive $4.5 million in rebates through the State of New Jersey Board of Public Utilities.[112] This rebate alone covered 45% of the initial costs to install the solar array and every year the solar array is in operation they have the ability to sell their RECs to help payback the cost. (For more information on REC see subheading below, under Financial Option)

The type of array is worth mentioning because of the option to concentrate the area in a field adjacent to the university. The concentration of solar panels allows the

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[108] "General Content Table of Contents." *LADWP*.
[109] ibid
[110] "Rutgers University Opens Seven-acre Solar Energy Facility, Accepts 2009 Energy Educator Award from State."
[111] "Conservation Update: Rutgers Breaks Ground on the Largest Solar Photovoltaics Power Facility in New Jersey
[112] ibid

array to harness the maximum energy without having to transport it from different locations. Even though Rutgers is considered an urban university they recognized the importance of having solar energy on campus and chose to use the available land.[113]

San Diego State University

San Diego State (SDSU) is a unique case for solar installation in that their projects have been completely done through a student lead organization on campus. The Associated Students (AS) of San Diego State University, the student government, partnered with Sullivan Solar Power to build a solar array on their campus.[114] Through the AS the Green Love Sustainability Board was established to construct a proposal for solar installation on the SDSU campus. In the Spring of 2008, the Board and AS council passed a self-imposed student fee increase in order to fund the solar project.[115] The solar project took two years to design and complete but was only one of several sustainable projects that the AS of San Diego State have sponsored and financed.[116]

This system is expected to save the university $35,000 a year and is the sole solar array on the SDSU campus.[117] At 124 kilowatts the system is small compared to those funded by the other institutions, but it is an excellent example of how students can impact their own university even without the financial assistance of the institution. This is the most productive example of how individuals that may not appear to have much potential

[113] "Who We Are | Rutgers, The State University of New Jersey."
[114] "SDSU Students Set Solar as a Top Priority, SDSU Students Make a Splash with Their Recent Solar PV Installation - PR.com."
[115] "SDSU Students Make Splash in Solar."
[116] "SDSU Students Set Solar as a Top Priority, SDSU Students Make a Splash with Their Recent Solar PV Installation - PR.com."
[117] ibid

for financing a solar project can overcome financial obstacles and raise the funds necessary to construct the project.

Financial Options

Power Purchase Agreements

The first and most prominent type of financial option is the power purchase agreement (PPA). This type of financial system works so that the college or university has no up-front cost. All cost of construction and installation are covered by the contracting company. This gives colleges the freedom to save their own money and at the same time receive more affordable electricity, all the while increasing their commitment to sustainable energy sources. This makes a college more sustainable instantly with no real monetary losses. The short term is a win for the college. The one draw back from this model is that the school does not own the array nor any structure that is built specifically for the array. This gives the college little maneuver capability if they choose to alter any part of the location that the array has been built on.

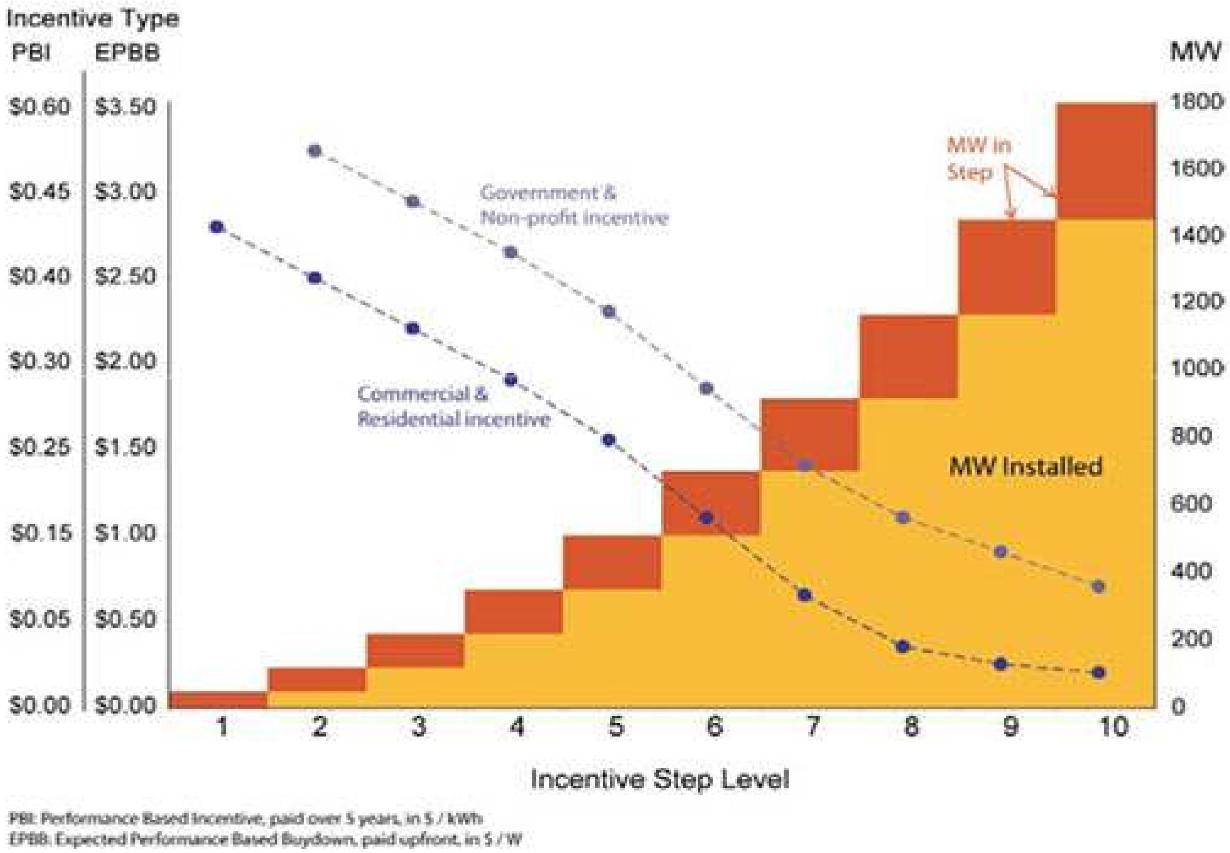
Arizona State University has been a model leader for the way in which solar energy can be implemented on a college campus. While they chose to use PPA's due to more legal constraints, they have found that this is the most cost effective way to implement large producing solar arrays. The idea of solar is not just to have a few panels to power a small percentage of electricity but rather to use different projects to continually increase the independent and sustainable energy on campus. PPA's give colleges a way to apply solar with no cost. ASU has found that they can do multiple large scale projects through PPA's to cover large percentages of the energy needs. This is all made available through the PPA with no initial costs, as opposed to a college funded array that draws money away from the school and other programs.

PPA's are also an advantage because the contracting company qualifying for all business rebates offered through the Federal Tax Credit. They also qualify for most state and local rebates. Non-profit organizations, colleges and universities, do not qualify for the solar Federal Tax Credit.

Rebates

Beyond PPAs, rebates are the most effective way to alleviate some of the financial burden of building a solar array. The Federal Tax Credit program for photovoltaic solar arrays only applies to homeowners and businesses or new construction of homes. For that reason I will focus on the state and local rebates. Most states including the largest of all, California, have solar rebate programs. The California Solar Initiative (CSI) gives performance based incentives (PBI) on a descending monetary scale (Figure 6). This program gives the owner of the solar array money based on the amount of kilowatts generated by the array. The amount of money per kilowatt is based on the incentive level in which you have built your array. In other words as more arrays are built the monetary incentives per kilowatt begin to decrease. The chart as follows.

Figure 6: California Solar Initiative Consumer Incentives[118]



For the California Solar Initiative the incentives for Government & Non-profit are higher than that of Commercial & Residential. This would actually give colleges and universities more incentive to build solar arrays because they actually receive larger rebates. Most other states including Arizona and Florida also offer incentives for solar energy. In Florida however, the rebate program is only offered to residential and commercial sectors. This leaves out very important governmental and non-profit sectors from installing solar energy. Arizona also has a program that only caters to residents and business but is considered to give the most money back in rebate program..

118 "The California Solar Initiative - CSI."

Other rebate programs offered through local utilities, as is the case for Caltech and LMU. LMU in partnership with the Los Angeles Department of Water and Power was able to cover the costs of their solar array through performance based incentives, where for every actual kilowatt of energy produced by the array Pasadena DWP pays the owner of the array a specific monetary amount. This model is effective because the utility provider, Pasadena DWP in this case, does not have to pay out large sums at one time to fund initial start up costs but has annual paybacks to help stimulate the local solar market. At the same time it helps the owner of the array to quickly payoff the debt incurred from financing a solar array.

In markets where PPA's are not available or applicable all rebates and performance based incentives should be used to help payback the costs of installing an array. This model is applicable for colleges because they have funds available for upfront costs of projects. If they are willing to invest the upfront cost then they will not only receive sustainable energy but that energy will actually save the institution in the long run. Solar arrays are expected to pay for themselves and through rebates and incentives these payback dates come quicker.

Renewable Energy Certificates

Another financial option comes in the form of Solar Renewable Energy Certificates (SREC). In this system the owner of a solar array is awarded one REC for every 1,000 kilowatt hour produced annually. RECs work in states that have mandated that utility companies produce a certain amount of solar energy. When utility companies do not meet their required amount they are regulated to pay a fine. In order to avoid fines they can purchase RECs on the open market. In a state like New Jersey that has this program, each credit is bought on the market for about $600.[119] To put this in real terms Rutgers University installed a 1.4 Megawatt Solar Array in May of 2009. They estimate that the array will produce enough energy annually to accumulate about $700,000 in renewable energy credits. Rutgers University has planned to use this program along with other rebates offered by the state of New Jersey to pay for its solar array. Based on calculations the array should pay for itself in approximately six years.[120] The only problem is that most states have not implemented REC programs because the state governments have not mandated utility providers to produce renewable energies. In a state where there are REC it is a very viable opportunity to help alleviate the costs of building an array.

Colleges can take advantage solar RECs by installing the largest possible arrays. In this program the credits offered are dependent on the energy production. Since utility providers are not meeting their requirements it is opportune to take advantage of the monetary incentives offered on the open markets of these REC states. Once again, institutions of higher education have the funds available for the programs but they need to commit to large scale applications in order to play a leadership role in the advancement of solar energy.

Self-Financed

When college solar projects are unable to use PPAs they have to fund some of the initial costs. Rebate programs do not offer much, if any, of the startup costs of solar

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[119] "SREC by State." *SRECTrade - Solar Renewable Energy Credit (*

[120] http://www.mycentraljersey.com/article/20091027/NEWS/910270360/Rutgers-officially-debuts-solar-panel-array-on-Livingston-Campus

arrays so colleges and universities are forced to fund the initial projects on their own. The funding for the project can come from various sources within a college. Colleges do not like to pull from their endowments because colleges pride themselves on the monetary value of their endowment and use it to further their own status in the world of higher education.

One argument being made is that a solar array can produce similar paybacks as the investments that endowments are in, if funded correctly. By saving the college money a solar array is actually considered an investment. Other than using the endowment a college may consider to use different financial means including bonds and possibly donors to pay for the array. This system however has its flaws because further funding for more solar projects may be harder to come by. Although, funding may become easier as long as initial projects are successful.

Another factor affecting the decision of solar energy is the rising price of conventional energy. As our fossil fuel resources begin to diminish and the price continues to rise, solar energy will become even more economically viable. Self-financing might seem like a cost to the installer but must be seen as an investment into a constant energy source that does not have rising energy costs.

Support

For a solar array to be successful there has to be support and pressure to move towards the more renewable energy source. This support needs to be spearheaded by more than one group at a college or university. The best model comes from both faculty, administrators and most importantly students. In order to finance a solar system there will be debate over the use of monetary funds toward the perceived non-academic program, especially since solar does not appear to directly affect the education or student life.

Support from students is an absolute necessity in understanding the importance of a college's commitment to be leaders and to produce innovation and progressive thinkers in an ever expanding world. Student led support exemplifies the importance to invest money and proves to the decision makers, most often a board of trustees, that this is a commitment worth making. Models from Caltech, Occidental, and San Diego State prove the importance of student led initiatives. These programs not only put pressure on the college or university to implement solar but also provides students with the opportunity to educate themselves in the development of sustainable energy. It also works to empower students in realizing that they have control over their source of energy production.

Caltech students have even taken the initiative to install a solar array of their very own. This model, while much smaller than the array the school built, shows the growing organized support for solar on the Caltech campus. Students of San Diego State started their own solar projects and are currently the only entity on their campus that has built a solar array. Occidental student led solar groups have collected petitions from the student body, urging the Board of Trustees to pass a proposed solar array. These are examples of the growing knowledge of college students around the subject of renewable energy.

Faculty support is also necessary because they can best understand the long term positive changes that solar energy will have on a college campus. Also, they recognize the educational tools that come from implementing a real project . From physics to environmental policy majors there are many of ways that a solar facility can affect the research and learning of students. Faculty may best understand the educational opportunities and the ability to integrate them into their curriculum. At Occidental College professors have predicted that more than 12 courses from four different majors can incorporate the function of a solar array on campus.[121] Faculty are also at universities longer than students and may have more of a vision for the college and the curriculum offered.

Administrators and board members must understand the monetary savings of a solar array and know that this is a long term investment that can capitalize on a relatively new industry.

Opposition and Concerns

Critics of a solar array have come by way of community members, students, and administrators.

At ASU students were weary of the idea that solar projects were being financed directly by their own tuition payments. This was an issue as tuition at the school had increased over the years prior to solar installation. Once ASU students were educated on the fact that the solar arrays were financed under PPA's and that the school has no initial costs to fund the project, their critical remarks were reseeded. This type of student opposition was due in part to the fact that there was a lack of organized student movement for solar energy on ASU's campus. Although ASU has great solar research facilities and incorporates projects into their curriculum the larger student body was not a

[121] Interview Dan Snowden-Ifft

focal point of support for solar arrays. Transparency of solar projects can solve problems of misunderstandings.

Opposition to the solar project at Occidental College has been projected to come from community members and their fears that open space will be lost. Occidental has a unique case in that they are an urban school that has chosen to place their array largely on an undeveloped hillside above the campus. Because of land value most other urban campuses including Caltech, LMU, and ASU, use rooftop space for their projects. The undeveloped hillside at Occidental can be accessed by the greater community and is considered one of the few local places that has been protected from development. Occidental has attempted to educate the community that the solar array project will not hinder their ability to use the trails on and around the hill. However, Occidental has rightful ownership to the land and can legally build a solar array on the piece of property. The opposition is not necessarily an obstacle but rather a concern from the community and not one the college is willing to overlook. In order to overcome the opposition Occidental will offer training seminars to community members on how they can finance their own residential solar project. Also, the potential company building Occidental's solar array, Martifer Solar, will offer a discounted price on their solar panels to local community members in order to finalize the Occidental project.

One concern that was brought to Caltech administrators was the possible removal of trees for the purpose of building the solar arrays. Even though the arrays are being built on the roof tops of buildings and parking garages, some of the tree's canopies stretch to cover the arrays and potentially block them from receiving their maximum solar energy collection. In order to deal with this problem the college took it upon themselves to replant the net loss of tees in other locations across their campus.[122] Along with this, they have decided to replant trees that are native to the area and are more drought resistant than the ones that are being removed.[123] This was a successful solution to those in opposition.

At both Caltech and Occidental there have been concerns over the aesthetic look of a solar project. The residential around Caltech were fearful that the solar projects would alter the appearance of the buildings which they were being installed. At Occidental residents were also concerns with the changing look of the landscape that would come with the installation of the proposed solar project. These two cases have been overcome through education and outreach. In terms of visibility, solar projects located on tops of roofs and parking garages are hard to see. As for an open hillside they may be more visible but can be built in more aesthetically pleasing ways, as is the case with Occidental College. (See Figure 4)

Community opposition comes from the lack of knowledge that individual people have on the details of what a solar project entails. It is said that the, "hardest thing is to get the first major project installed."[124] Once a project is installed and people realize the advantages of having a solar array they become more accepting to the idea of more solar projects. Solar will continue to be question by those that do not fully understand it.

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[122] "Solar Power Production at Caltech." Cowell pg.9
[123] ibid
[124] Bentzin, Bonny. *Arizona State- A Leader in Solar*.

Conclusions

Understanding how colleges can implement solar projects is the most important lesson to be learned in this report. Financing places a major role in the ability for a college or university to construct a solar array. With the current financial market in most states, other than those with solar REC programs, the best financial option is a power purchase agreement. The no upfront cost to the college enables the institution to continue investing in programs and projects that closely relate to the student, while at the same time installing a reliable and sustainable energy source on campus. The same educational outreach and student involvement programs need to be made available in the PPA model, in order to ensure that all possibilities and potential are fulfilled from a project of this magnitude.

If a PPA is not available, as is the case in particular areas including Los Angeles Department of Water and Power district, then all resources for rebates and performance based incentives must be exhausted. The money that can be earned back will help to formulate the array as a strong economic investment. Financing the additional portion of the array will be the hardest obstacle to overcome, but it is important to remember that the solar investment is not only beneficial to the environment but also to the educational institutions role as a leader in the future of our world, is just as beneficial. Obstacles and opposition is inevitable but through education and transparency much of the concerns can be overcome. For those that cannot be convinced through education then there are many other options to help compromise the concerns in order to build the project.

The vision and drive for solar projects must come from more than one entity of a college in order to have the continual support. Even in the case where the administration is committed to s solar project on campus, the most successful solar projects will include a student led aspect. The student participation is important because it enables students to question the project and educate themselves on the advantages and disadvantages of solar.

Education institutions are fundamentally important leaders in our world today. Society expects these places to have the most advanced well formulated ideas. But as society looks to colleges and universities to solve many of our problems we face today, institutions of higher education must take a more active role in the application of their findings and research. To not apply ones research results in the overall loss of a vital opportunity to physically and visibly illustrate the progress that has been made.

Solar is an industry that has the potential to provide a significant portion of our total energy needs. To this point there has been a severe lack in consumer awareness and participation. Institutions of higher education must play a major role in furthering the growth of the solar industry by way of their own solar projects and educational outreach to both the college students and the greater communities. As solar projects become visible across college campuses it will change the culture of solar energy. There are 4,352 colleges and universities in the United States that teach more than 17 million students.[125] If every college had a solar project than there would be the potential that at the very minimum 17 million people would be educated on the opportunities of solar. We trust colleges to educate our young adults and it is about time we start doing so in the field of solar energy.

[125] Neuharth, Al (1 May 2009). "College Decision Day". Melbourne, Florida: Florida Today. pp. 11A.

Recommendations

In order to reduce our dependence on fossil fuels to supply are energy needs we must make energy producers take responsibility for implementing renewable energy projects. In order to create a more competitive market for renewable energy resources there must also be subsidies for all sectors of our economy, not just residential and commercial.. While taking a national look at the ways in which to solve our energy crisis we must remember that local energy supplies will be the most reliable, efficient, and productive. In places that have abundant amounts of sun we must capitalize on that resource and in others where there is wind, geothermal or other opportunities we must do the same.

As colleges and universities continue to develop solar technology it will be important to financial assist them in building solar projects in order to further the technological growth of solar. With concrete projects on college campuses it will be easier to further that technological growth because they can learn from the experience and best resolve any issues or advancements that may be made . Therefore, policies must be established to assure that colleges have the monetary incentive to build solar arrays. These incentives must come through rebate offerings. Current federal rebates are only offered for the business and residential sectors but must be extended to include the non-profit sector, which accounts for more than 12.5 million jobs.[126] Another option for rebate programs comes through the individual states and must once again include all sectors. The California Solar Initiative has a great example of their commitment to the non-profit and governmental sectors in offerings them higher return rates than those of

[126] https://www.independentsector.org/resources

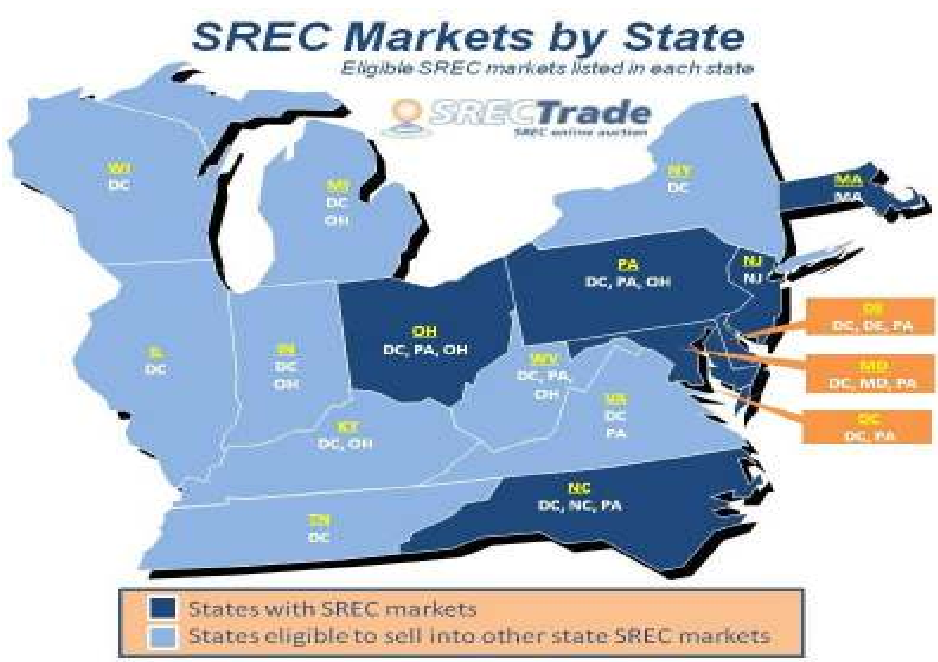
residential and business (See Figure 6). Rebates refers to the performance based incentives models that are already being used. These will help the owner of a solar array to payback the cost of their project. The payback periods may differ but must ultimately assist in financing upwards of 50% of the entire project. However, there needs to be policies in order to help subsidized the initial costs of a project. This can be funded through different levels of government but may best be established by local utility providers. The initial start-up costs are a deterrent to solar builders and to subsidize these costs would give incentives to construct solar arrays.

Government subsidized programs are important because they help solar energy projects economically compete with the older fossil fuel based energy providers. One model for these rebate programs would be for the federal government to provide a performance based incentive that would pay an annual amount to the owner of the array based on the number of actual kilowatts produced by the solar panels. The time period would last three to five years depending on the size. The larger arrays would receive paybacks for more years in order to incentivize builders to construct larger solar arrays. Larger arrays are beneficial because they provide more overall energy. In order to fund the start-up costs local utility providers should be required by state legislature to provide expected performance based buydowns (EPBB) which are paid upfront. The funding would cover 20-25% of the initial start-up cost and would help solar become more competitive. Currently this type of funding is offered either only to small projects or as a secondary option to the PBI model. The PBI and EPBB programs need to work together to provide the best incentives for installing solar energy.

All federal, state, and local programs should be slowly phased out so that after specific amounts of installation the rebates and incentives decrease. The current phase out periods offered by different governmental programs occur much too short. By keeping the incentives high there will be more growth and technological advancement in the industry. One example of a quickly phased out program is that of the California Solar Initiative. After 400 megawatts of solar installation of the residential and commercial sector the price of performance based rebates drops from an initial level of $0.45/kw to a level of approximately $0.10/kw.[127] The drastic decrease needs to be changed so that the periods over which the rebates levels are offered last longer than where they are today.

Another way to facilitate growth of the solar industry is to require utility companies and other energy suppliers to produce a specific percentage of electricity through renewable sources of electricity.

Figure 7: Solar Renewable Energy Credit Market[128]



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127 http://www.gosolarcalifornia.org/csi/index.html

128 http://www.srectrade.com/

Figure 7 illustrates the solar REC available on the East Coast of the United States. Currently, this is the only REC program available for solar energy in the country. A program for solar REC should be extended to all states by requiring energy providers to produce a specific percentage of energy by way of renewable sources. Within this program each state would be mandated to provide a market for renewable energy credits in order to allow for there to be more economic incentives to implement solar. All states must mandate that their energy providers produce upwards of 20% of electricity through renewable energies over the next five years and if they do not then they must pay a fine. In order to meet the required level of renewable energy supply the providers can buy renewable energy credits. These REC programs will give other businesses and residents the opportunity to help finance their own solar projects through selling back solar energy credits. The owners of the solar panels would now be able to sell their credits to the providers in order to payoff the cost of their solar project. This also creates more local energy supplies, as any builder would be eligible for the REC program, and would further reduce our dependencies on power plants and their fossil fuels.

Creating local networks of renewable energy also needs to be a point of emphasis. Since energy is lost during transportation it is important to maximize efficiency so that the energy supply is located in close proximity to the consumer. Building solar arrays hundreds and even thousands of miles away is not ideal. That is why more local and regional supplies need to be financed and developed. If single family homes and commercial buildings have the potential building space to become energy independent through renewable sources then policies should capitalize on those opportunities. Not to say that large fields of solar and wind power do not have their place, because they do, but that should not be the first priority. To create self-sustainable places our society should not have to develop large acres of land to provide resources. Further policies should inhibit the large and remote solar fields and instead incentivize local projects.

Further Research

More studies need to be done on the potential that neighborhoods, cities, and regions have in supplying their own energy needs. I would ask what is the rooftop availability of different types of cities and what is the potential for those underutilized spaces to be converted to accommodate solar panels? There is tremendous potential for single family residences to independently provide their energy needs. But what is the feasibility of commercial, manufacturing, and industrial sectors to become self sufficient in their energy supply? Are there ways to implement solar on rooftops, parking garages and lots of these non-residential places? Analyzing the potential energy self-sustainability of different places will play a key role in developing policy incentives to help facilitate growth.

Afterword

In the Spring of 2010 Occidental College Board of Trustees approved the proposed 1 megawatt solar array. This was due in part to the efforts of Dan Snowden-Ifft, Urban & Environmental Policy department, Student Solar Committee, Sustainability Committee, and all others involved. The passage of this project illustrates the significance that Occidental College has placed on the importance of reducing our carbon emissions through an on site power generation system. The hope is that this solar project will be the first of many projects towards the reduction of our greenhouse gas emissions. I personally am grateful that Occidental College has taken the initiative to become a leader in solar energy. Thank you to all.

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