Solar on Skidmore:

The Bright Beginning to Renewable Energy on Campus

Environmental Studies Senior Capstone

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Skidmore College

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Introduction

Background

The ability to meet the energy needs of future generations depends on the availability of reliable, clean, and safe energy sources. Currently, the United States' energy consumption habits depend on foreign fuels, therefore contributing to the country's dependence on foreign nations, and creating vulnerability for future American-energy needs. Between 2010 and 2011 alone, the average price paid for petroleum, which accounts for nearly two-thirds of all energy imports, increased 56% (US EIA 2011). While the United States currently relies on energy imports to buffer the gap between the increasing energy consumption and the energy produced within the country, American consumers bear the costs of the unstable price in the market for foreign fuels.

The United States' domestic fossil fuel generation is in decline. Despite moderate growth between 2001 and 2007, net energy production in the United States is steadily declining, concurrently, average electricity prices are rising (Appendix A) (US EIA 2012). This trend is especially noticeable in the consumption and production patterns of the Country's top domestic energy source, coal, which has been declining since 2007 (US EIA 2011). Coal, natural gas and crude oil compromise the top three sources of American energy production; these sources have alternated as the primary source since the 1950's. In the middle of the 20th century, crude oil and natural gas became the primary sources of energy production in the United States (US EIA 2011). However, by the mid-1980s, coal became the leading energy source produced in the United States, although in 2010, natural gas production exceeded coal production for the first time since 1981 (US EIA 2011). Since fossil fuel supplies are consumed faster than then they are formed, our country's reliance on such limited fuel sources further threatens future energy security. In order to maintain greater economic stability and energy supplies, liberation from our national dependence on fossil fuel imports is necessary.

Considering the top three energy production sources are fossil fuel based, electricity generation in the United States is a dirty business: it is the single largest source of greenhouse gas (GHG) emissions in the United States (EPA Emissions 2011). The fossil fuel combustion process of most electricity in the United States produces GHGs, which cause solar radiation to remain in the Earth's atmosphere. When solar radiation remains in the atmosphere, it warms the Earth's surface. In excess, the GHGs in the atmosphere drive long-term climate changes (EPA Emissions 2011). The predicted effects of climate change are global and include natural disasters such as sea levels rise, oceanic acidification, spread of disease and extreme weather events. These effects threaten fundamental health necessities for both social and environmental communities (McCarthy 2001; WHO 2009; IPCC 2007). Health and environmental concerns associated with GHG production can be addressed through the development of a clean, renewable energy infrastructure and market.

Unlike standard fossil fuels, renewable energy sources, such as hydrologic, wind and solar, do not emit direct GHG emissions and are accessible domestically (Braverman 2011). In fact, the renewable energy market in the United States is a major source of growth in the domestic energy production market, passing energy production from nuclear in 2011 (Gies 2011). The continuing expansion of clean, safe and sustainable energy sources will not only stimulate domestic energy markets and clean-energy job production, but it will also promote human and environmental health, and strengthen national security.

Goals

In response to the growing need for renewable energy, the goal of this study is to provide Skidmore College the information and analysis regarding the technical and financial feasibility of three solar installations scenarios.

The possible solar installation sites include:

- Scenario 1 a 414kW solar installation on the Williamson Sports Center;
- Scenario 2 a 24.8kW solar installation on the Williamson Sports Center; and
- Scenario 3 a 24.8kW solar installation on the Van Lennep Riding Center.

These sites can be found on campus map in Appendix B. The feasibility of each scenario is assessed with consideration to the technical requirements and specifications for each scenario, in addition to the financial cost options and payback period. In addition to our feasibility analysis of each scenario, we consider the intangible benefits, as well as long-term benefits of a solar installation at the College.

Skidmore's GHG Report

During the academic year of 2008 to 2009, Skidmore conducted a greenhouse gas report that "quantifies the gases released by college related activities" (Marsella et al. 2010). The Greenhouse Gas Report established a baseline for current emissions, and thus providing data necessary to begin discussions at the College regarding carbon reduction initiatives.

Skidmore hired Loyalton Group, an outside energy management firm, to conduct a comprehensive energy consumption report, which created the foundation of the Greenhouse Gas Report. Skidmore identified three emissions categories, referred to as 'Scopes.' "Scope 1 is the direct emissions that are owned and controlled by the College," including emissions from gasoline, oil, natural gas, diesel, propane, and refrigerants (Marsella 2010). "Scope 2 is the indirect emissions that are from [the] purchase of power," for Skidmore's electricity (Marsella 2010). "Scope 3 is indirect emissions that are a result of activities related to the College, but are not owned or controlled by the College" (Marsella 2010). This scope encompasses all travel by faculty and students to and from campus, as well as academic, athletic and business travel. Scope 3 addresses individuals' GHG emissions, such as the emissions from traveling to study abroad, which is difficult to alter without sacrificing opportunities. Scope 1 and 2, account for about two-thirds of Skidmore's GHG emissions and are the primary focus of current and future efforts in carbon reduction efforts, due to their tangibility for Skidmore to change and control (Marsella 2010).

To address Scope 1 emissions, Skidmore has installed geothermal heating, ventilation and air conditioning (HVAC) systems in three buildings on campus, and there are three more geothermal HVAC retrofitting projects underway (Hall, 2011; Sustainable Skidmore). Upon completion, approximately 36% of the College's HVAC energy needs will be met by the geothermal systems (Hall 2011). Additionally, there are geothermal plans for the Dance Center, Wiecking Hall (Appendix B) and the new science building to be constructed. These additional projects would meet another 14% of the HVAC demands. With around 1.5 million square feet of monitored climate control on campus (Hall 2011), installations of geothermal HVAC systems around campus have resulted in over 65% energy cost savings (Marsella 2010).

To address Scope 2 emissions, a number of projects have been implemented at Skidmore since 1998, resulting in major electricity savings. One project was a large-scale lighting switch to more efficient light bulbs. The project cost around $1.3 million, but has saved the College 5 million kWh in electricity (Hall 2011), ultimately reducing the campus electricity bill. This project had an exceptionally short payback period of 4 years. Another project that reduced Scope 2 emissions was the decentralization and replacement of the three central heating pumps on campus, which were replaced by 29 individual boilers. The original three central pumps were relatively inefficient, and had significant heat loss from the ground (Hall 2011). The decentralization of the heat pumps resulted in major reductions in heat loss, and additionally saves the College around $400,000 and 34,000 dekatherms in natural gas use annually. There is an ongoing effort to assess the College's total energy usage, with anywhere between 10-30 projects currently being examined for financial and technical feasibility for application on campus (Hall 2011).

While major achievements have been made in reducing electricity use, the College still consumes around 22 million kWh/ year (Hall 2011), and relies on energy purchases from external generators. The generator from which electricity is purchased is decided by the lowest bid (price) offered to the College. This means the electricity supplier changes regularly, therefore so does the resources used for energy production. Currently, the College's 2012 energy provider is Direct Energy Hess, while the 2011 provider was Hess, and the 2010 provider was Suez Energy (Hall 2011). While this system of price bids offers the College an opportunity to take advantage of dynamic prices and maintain a low purchase price, it produces electricity prices that do not reflect the general market trends, and therefore can be difficult to forecast future pricing. In an effort to address the environmental impacts of electricity consumption, the College purchases renewable energy credits (RECs)[1] (Hall 2011). While noteworthy steps have been made by the Facilities Services at Skidmore College to implement energy, and carbon-footprint-reducing projects, energy purchases remain a point of vulnerability for the College as electricity price fluctuations and natural resource limitations threaten future energy supply and availability.

Further Reduction Options

In order to develop a broader renewable energy infrastructure, Skidmore could establish a renewable portfolio standard (RPS), just as New York State[2] has done, to establish and work towards renewable energy goals. Specifically, a RPS mandates that a designated amount (or percentage) of overall electricity production or purchase comes from renewable sources, with increasing goal increments (Rabe 2007). Developing a RPS at Skidmore would ideally help the College to implement renewable energy initiative and meet carbon reduction goals.

In evaluating the College's renewable energy potential, one renewable energy source that has been considered previously by the College is wind. In 2010-2011, Skidmore student Drew

[1] About 2 million kWh, which equates to about 9% of the Skidmore's electricity consumption, worth of RECs were purchased in 2011, and plans of increasing the amount of RECs purchased to 3.5 million kWh were outlined for 2012.

[2] New York's RPS includes obtaining 30% electricity from renewable resources by 2015.

Levinson'12 conducted a feasibility study of a building integrated wind project on campus. Levinson found that the initial investment of the wind turbine would cost the college $300/year over a 10-year period. The proposed turbine would produce 600 kWh of electricity, and would offset $72 in yearly electricity costs (Levinson 2011). Skidmore is generally attracted to projects with a payback around 7 or 8 years (Kellogg 2011), therefore Levinson concluded that neither the payback period nor the energy produced by a wind turbine installation would be significant enough to justify the initial investment.

Another renewable energy is solar photovoltaics (PV). Although Skidmore has considered solar installations in the past (Hall 2011), technology advancements in the solar industry, changing grant opportunities and shifting electricity prices can elicit new feasibility outcomes. Solar PV systemsoutcome an attractive energy sources because they provide essentially maintenance-free, predictable energy output after installation and can be used in a range of locations and scalable sizes (NYSERDA.a. 2011). Therefore, solar should be reconsidered as an option in expanding Skidmore's renewable energy sources.

Strengthening Skidmore's renewable energy portfolio is essential to reduce the College's carbon footprint, maintain a stable status in fluctuating energy markets, and to increase energy security in planning for future energy needs. Consideration of solar PV as an electrical power source could benefit the College because it would serve to reduce greenhouse gas emissions by offsetting a portion of the electricity consumption, thus offsetting a portion of the electricity price and laying the foundation for potential savings in the future.

Technical Considerations

As indicated in the goals of this study we focus on three specific scenarios for solar on Skidmore, illustrating different locations and sizes of solar installations on Skidmore's campus. Scenario 1 and 2 consider the Williamson Sports Center roof as the potential site for a larger and a smaller size solar installation respectively. The Sports Center was chosen as a site of analysis because of the significant size of the roof, and the ideal location of the roof, which faces near due south. Scenario 3 examines a solar installation on the Van Lennep Riding Center (the Stables), Skidmore's horseback riding facility located on Daniels Road. The Stables was selected as another location because the roof on the Stables is scheduled to be replaced within the next year, and its orientation is near due South. The descriptions of the case scenarios are as follows, and Table 1 provides an overview of all three scenarios.

Table 1   Scenario Descriptions[3]

Scenario Number	Total System Size (kW)	Number of Panels	AC Output (kWh)	Installation Cost ($)	GHGs offset (metric tons)
One- Sports Center Lg	414	1800	487,201	1,490,400	335.98
Two-Sports Center Sm	24.84	108	29,229	89,424	20.16
Three- Stables	24.84	108	29,820	89,424	20.56

Construction Considerations and Assumptions

Roof Weight Load

A major concern for any solar installation on a preexisting rooftop is whether the roof will be able to support the additional weight from the solar panels and racking structures. Solar panels add an additional 2.5-3.5lbs of weight per square foot (psf) to the roof's weight load (Wiltshere 2012). This additional weight load is minimal, and the Building Code of New York State (BCNYS), as well as the previous New York Uniform Fire Prevention and Building Code (NYBC) already requires a dead load and snow load weight threshold, in order to take into account loads such as snow and foliage (Rivers 2010). The additional weight load from a solar installation should generally fall within the additional dead load and snow load capacity; therefore, as long as the rooftop was constructed in accordance with the BCNYS or NYBC standards, a solar installation should not pose a significant issue in terms of weight load.

Scenarios 1 and 2 present the greatest concern with respect to weigh loads. One reason for concern is that the Williamson Sports Center roof was recently replaced, and considertion for solar threshold weights were not included in the construction. Therefore, the roof would need to be further retrofitted in order to support a solar installation. Additionally, the Sports Center roof was reviewed by an engineer post-replacement; the engineer report includes concern about if the roof replacement had adhered to the necessary building codes, especially with respect to the necessary additional weight threshold needed for snow (Rivers 2010). Assuming that all building codes were met during the roof replacement, the engineer report suggests that the roof would be able to maintain a solar installation while remaining within the safe weight threshold. However, the engineer states that, "it is possible the building's supplier did not adhere to the NYBC and instead designed for snow loads published in one of the other model building codes. If that was the case we would not recommend the addition of any roof loads" (Rivers 2010). Because of this certainty, further review would need to occur prior to any installation at this site.

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[3] *Methodological details are available in Appendix C.*

Scenario 3 proposes a solar installation to be built upon a roof that is yet to be constructed; therefore this scenario provides an opportunity to design and construct a roof that accommodates for a solar installation.

Roof Type and Construction

Another consideration to take into account is the type of mounting system that would be used. Depending on the types of roofing material (i.e. corrugated metal, ballasted, shingled), different racking systems may be used--some more economically or technically feasible than others. Mounting that requires the penetration of roof surfaces is not preferred because such a mounting style can void a roof warrantee and compromise structural integrity (Elphick 2012). Thus, non-invasive racking systems are generally recommended, and our analysis infers such mounting methods. With regard to future roof construction where solar is considered, such as the Stables, we recommend a corrugated metal roofing material. A simple racking system is relatively easy to install on this roofing material.

While future construction methods and materials are essential to consider in maximizing solar potential, electricity prices and trends additionally influence the impact of solar at Skidmore.

Installation and Electricity Cost

As discussed, Skidmore College uses an electricity bid system to determine monthly prices. Because of this system, electricity prices are less consistent, but more competitive, than if the College were bound by a long-term contract. Bids for electricity pricing generally cycle every year or two, but in the last few years, Skidmore College has used five different suppliers: GDF Suez, Hess Corporation, Direct Energy, and Gateway Energy Services (Ahmann 2012).

Although the College has a fixed, or 'locked' electric commodity, real pricing for the College varies due to changes in peak demandDuring times of high demand (peak hours), charges for surplus demand are added to the 'locked' price. The annual average price of electricity, as well as monthly average prices, does not illustrate the true fluctuations of electricity prices (Ahmann 2012). Within a year, electricity prices between months have been shown to fluctuate by as much as \$0.09/kWh—which is approximately equal to the current 'locked' price of electricity accepted at the most recent bid cycle by Skidmore College (Ahmann 2012).

For this study, solar prices are compared to the current base price of \$0.091/kWh, with acknowledgement that the actual price paid monthly varies greatly. An average annual electricity growth rate of 5% was used in our calculations, based on energy industry models (Elphick 2012; Wiltshere 2012), and supported the in the College's electricity price trends observed in the last half decade.

Financial Review

The high initial cost[4] of a solar installation poses a challenge for the College. Considering this obstacle, the only way to make solar financially feasible for Skidmore is to look for outside funding that would reduce the installation cost significantly. This section provides two different financial options Skidmore could pursue for a solar project. These options are grants and a power purchase agreement; both options are widely used for solar projects and have unique advantages and disadvantages that are discussed below.

As a higher education institution, Skidmore College has a very different financial profile then a private company. Therefore, our financial review focuses on opportunities and case studies that are specific to universities and colleges. The first step in exploring different financial options for a solar installation at Skidmore is to look at solar projects by Skidmore's Peer and Aspirant Schools[5].

Over one third of Skidmore's Peer and Aspirant Schools have some type of solar installation[6] on campus, with the majority of our Aspirants Schools having solar on campus[7]. Appendix D includes a brief description of each solar project. Many of these projects were funded through either a grant or power purchase agreement.

Government grants for solar include funds on the federal level such as money allocated to construction projects under the 2009 American Reinvestment and Recovery Act (ARRA), which was used to stimulate the United States' economy after the 2008 recession. Bowdoin College, an Aspirant School, received a total of $100,000 from the ARRA to install solar thermal panels on their Thorne Dining Hall between 2010 and 2011. These panels offset the emissions from the natural gas required for their steam-to-water heat exchanger system (Bowdoin 2011).

Money from the ARRA is no longer available; however, there are other grant opportunities for solar projects on campuses. Wesleyan received a grant from Connecticut's Clean Energy Finance and Investment Authority for the construction cost of a 203 kW PV system on their Freeman Athletic Center (Staye 2012). This grant supplemented over half of the installation cost, and without it, the project would have not been feasible. With the grant, the payback period for this project was 12 years, which is high; Wesleyan usually looks for a payback period of 6-8years. Even though the payback period was not very attractive, Wesleyan "wanted a highly visible statement of [their] commitment to alternative energy, and felt that the grant funds provided an opportunity too outstanding to refuse" (Staye 2012).

[4] The proposed installations are calculated using an average of $3.60/ installed (DC) watt. This is an approximate and comprehensive average price of solar, internalizing the associated installation and equipment costs to provide a comprehensive price of electricity that can be compared to the grid price. This is calculated by dividing the panel, equipment and installation costs by the number of watts the system would produce.

[5] Peer and Aspirant Schools are schools that have similar characteristics and attributes as Skidmore College. This is a list used to compare Skidmore's efforts and initiatives to comparable insitiutions.

[6] Solar installations include both solar thermal and PV systems.

[7] This information was compiled through a search of renewable energy efforts of each school via the internet. The Peer and Aspirant School list is the list used in the "Environmental Coordinators and Initiatives" (Skidmore College, n.d.)

In addition to grants, some schools have engaged in power purchase agreements for solar projects. Wesleyan and Smith College (not a Peer or Aspirant) have used power purchase agreements for solar, and Wesleyan is considering an additional power purchase agreement project on campus. Power purchase agreements (PPAs) are a common financial agreement to fund solar projects. In a PPA, there is a host and a third party investor; the host supplies the space (roof) and the third party investor pays for and owns the solar panels. The host then purchases the solar electricity from the investor. This arrangement is especially useful for host organizations who cannot afford the high startup costs of solar.

Additionally, PPAs are attractive to third party investors for several reasons. For PPAs that involve a non-profit as the host, an investor can benefit from government tax incentives that the non-profits cannot. Tax breaks can be extremely attractive for third party investors as an incentive to invest in renewable energy projects.

Another incentive for third party investors is renewable energy certificates (RECs). RECs are the commoditization of renewable energy benefits and create a tradable credit market between renewable energy producers and electricity utilities. In a REC system, entities who own renewable energy sources like a wind turbine or solar panels own an allocated amount of RECs. Electricity companies are required to produce a certain amount of their electricity from renewable resources, when they are not able to do this internally, they can buy RECs as credit towards their renewable quota[8]. In a PPA, the investor owns the RECs and can sell them for a profit. Finally, third party investors will negotiate an electricity price that will be profitable. Investors are able to do this by reducing the upfront costs of the installation through the first two benefits.

In a PPA, the host benefits in several ways. The first is the presence of solar on campus, which has many intangible benefits[9]. In addition, since the host negotiates an electricity price with the investor, there is a set price for electricity from the panels for up to 25 years[10]. A consistent electricity price can be especially attractive given the volatility of electricity prices from the grid. Ideally, in a PPA, the solar host negotiates an electricity price that is competitive with their current and projected electricity prices from the grid, thus making the agreement financially beneficially to all parties involved.

The aforementioned PPAs and many of the grants utilized by our Peer and Aspirants were facilitated through state level support and the current state politics towards renewable energy were pivotal to the financial success. New York is especially aware of the need to expand the its renewable energy infrastructure since the average New York resident pays almost 50% more than the national average for electricity ($/kWh)(BLS 2012). New York has also established a renewable portfolio standard (RPS) in order to reflect these goals. The current RPS requires new policies and initiatives to increase the proportion of renewable electricity by retail

[8] For a further discussion for RECs see Appendix F.

[9] See page 14, "Intangible Benefits"

[10] An average 'lifetime' of a solar panel: when it produces at least 80% of the original, installation output under warrantee.

customers, specifically there is a goal for New York to obtain 30% of its electricity from renewable resources by 2015 (NYSERDA 2011).

Additionally, the New York State Senate and Assembly have seen several bills in recent legislature that seek to establish a system of renewable energy credits (RECs)[11]. While the State RPS currently dictates renewable energy goals, the establishment of a REC system would require electricity suppliers to procure a specific amount of their energy supply from renewable energy sources, thus creating a market and funding the sources for renewable energy. Solar renewable energy credits (SRECs) for example, would be sold by solar energy producers, and electricity suppliers would have to buy a certain percentage of SRECs each year in order to comply with RPS standards and state initiatives. This system of RECs would create an additional source of revenue for installed renewable energy systems.

Scenario-specific Financial Outlooks

Scenario 1-

Given the size of this scenario (Table 1), there are limited grant options for Skidmore. The best option would be a PPA where Skidmore could engage a third party investor who would benefit from the tax breaks. The key to a PPA for Skidmore would be to negotiate a price for electricity that is competitive to their current rate. For example a PPA with a stable electricity price between $0.10 and $0.15 may not be attractive when compared to the current electricity; however, in the long run, as grid prices increase, the stable PPA price would produce significant savings. A traditional PPA structure will require Skidmore to speculate a price that will be currently competitive and remain below the future grid price.

An alternative to the traditional PPA is a new PPA structure, in which the PPA electricity price is ‘pegged’ to the grid electricity price, is another funding-structure option for Skidmore. In this structure, the PPA price is set “x” percent or cents below the grid price (Elphick 2012). Therefore, Skidmore would be guaranteed a PPA price less than their grid electricity, but the PPA price would still follow the increasing trend of electricity prices. In a pegged PPA, there is also more variability than a classic PPA structure, since it will follow price trends.

To begin PPA negotiations, Skidmore College would have to submit a request for proposals from different solar contractors and evaluate the proposals. Each proposal will consist of a proposed PPA structure with possible investors and terms of business. The Sports Center may pose a challenge for investor confidence because on concern considering the roofing structure and how it may be perceived as a liability risk to (Elphick 2012).

Table 2 demonstrates the finances of Scenario 1. Since Scenario 1 is not eligible for any current NYSERDA grants and a possible PPA would require a leap of faith (Staye 2012), Table 2 demonstrates the cost and payback if the College financed and paid for the installation on its own. The payback period for all the scenarios was calculated in net present value, with an assumed 3.5% inflation rate.

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[11] Such as the New York Solar Industry Development and Jobs Act (S.4178 [Maziarz] “same as” A.5713 [Englebright])

Table 2- Financial Details for Scenario 1

Total System Size (kW)	**AC Output (kWh)**	**Installation Cost ($)**	**Grants Available ($)**	**Payback Period (NPV in Years)**
414	487,236	1,490,400	0	49

Scenario 2-

The size of the solar installation in this scenario is ideal for a state level grant for which non-profits are eligible. Within the New York's Renewable Energy Portfolio Standards (RPS), there is a focus on "custom-sited tier" renewable energy efforts[12]. Custom-sited projects are small-scale generators that are site specific (NYSERDA 2011). A solar installation on Skidmore's campus would be a customer-sited tier, and there are several funding opportunities for these types of projects. For Skidmore there is the PON 2112- Solar PV Program Incentives (PON 2112), which provides cash incentives for the installation of grid connected photovoltaic systems. PON 2112 has a 25 kW installed solar capacity limit for which for non-profits like Skidmore. PON 2112 is also set to expire in 2015, therefore funds are are time sensitive. Table 3 demonstrates the finances for Scenario 2. With PON 2112, the cost of this installation is reduced by 50%, demonstrating the potential affordability of solar with a grant.

Table 3- Financial Details for Scenario 2

Total System Size (kW)	AC Output (kWh)	Installation Cost ($)	Installation Costs w/ Grants($)	Difference in Costs	Payback Period (NPV in Years)
24.84	29,234	89,424	45,573	49% Reduction	29

Scenario 3-

This scenario could also utilize PON 2112 because the size of the project is less than 25kW. In addition, if the Stables roof is being replaced, depending on the extent of the

[12] New York State Energy Research and Development Authority (NYSERDA) oversees the RPS and provides grants to help achieve the RPS. For more information on NYSERDA grants see Appendix E.

construction, there is the New Construction Program offered by NYSERDA. Although this program is focuses on new construction, projects that include substantial renovations are also eligible. As long as the building is out of service for at least 30 consecutive days (NYSERDA 2011).

The New Construction Program provides technical assistance in evaluating energy-efficiency efforts, and funding is available to offset additional costs associated with the purchase and installation of approved efforts (NYSERDA 2011). There is no size limit for this program, and it provides flexibility, as well as technical support, to qualifying parties in finding renewable options for their site. There is not a set monetary reward; rather, financial support is handled on a case-by-case basis. Projects that have already taken advantage of this program have received between \$50,000 and \$100,000 from NYSERDA. For Scenario 3, we predicted Skidmore would receive a reward of \$25,000.

An example of the successful application of the New Construction Program is the Hudson Valley Community College Tec-Smart Building in Malta, NY. This building functions as an education center and pillar of state-of-the-art green technologies. The building is also currently eligible for LEED Platinum Certification (NYSERDA, 2011). NYSERDA assisted with solar-electric and wind-turbine power installations for this building. In total, NYSERDA's incentive rewards for this building amounted to \$616,363, with a simple payback period of 5.8 years (NYSERDA, 2011).

Table 4 demonstrates the finances of Scenario 3. This table considers if Skidmore received just PON 2112 and if Skidmore utilized both PON 2112 and the New Construction Program for an installation of the Stables. It is evident that the New Construction Program significantly reduces the cost of this installation, with the two grants combined the installation cost is reduced by 70%; this reduction suggests the School should consider this opportunity in their construction plans for the Stables' roof replacement.

Table 4- Financial Details for Scenario 3

	Total System Size (kW)	AC Output (kWh)	Installation Cost (\$)	Installation Costs w/ Grants(\$)	Difference in Costs	Payback Period (NPV in Years)
NYSERDA Grant	24.15	24,3523	89,424	42,164	53% Reduction	24
NYSERDA + New Construction	24.15	24,353	89,424	27,164	70% Reduction	17

It is evident from the financial details for each scenario that a solar installation would have a higher payback period than many successful projects in the past. However, there are other economic implications of a solar installation that should be considered when reviewing the economic feasibility of solar on Skidmore. These implications include the current variability in the annually electricity price and the predicted growth of future electricity prices.

Electricity Price Changes and Implications for the Future

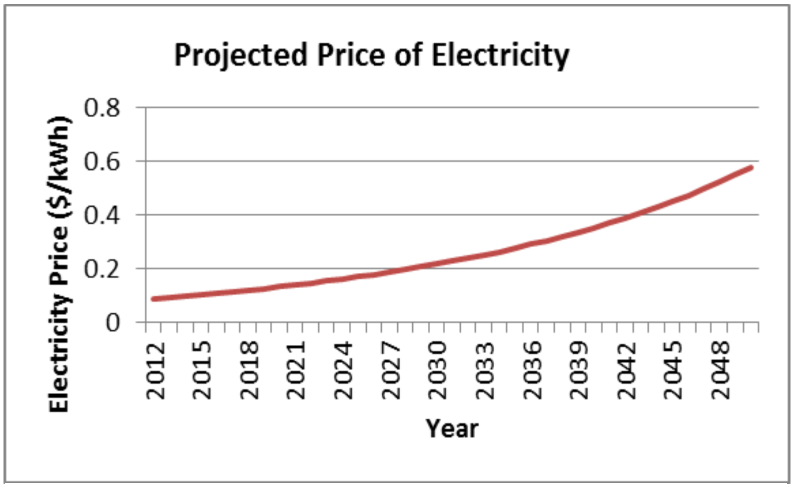


Figure 1 Electricity price increase with assumed 5% increase

Electricity Price Increases

In considering the predicted 5% electricity price increase constant, and using a base price of $0.091/kWh, the price of electricity for Skidmore will be $0.57/kWh in 30 years (Figure 1). Looking at the long-term electricity prices are essential when considering new renewable energy projects such as solar, because energy price increases significantly impact the payback period of such projects.

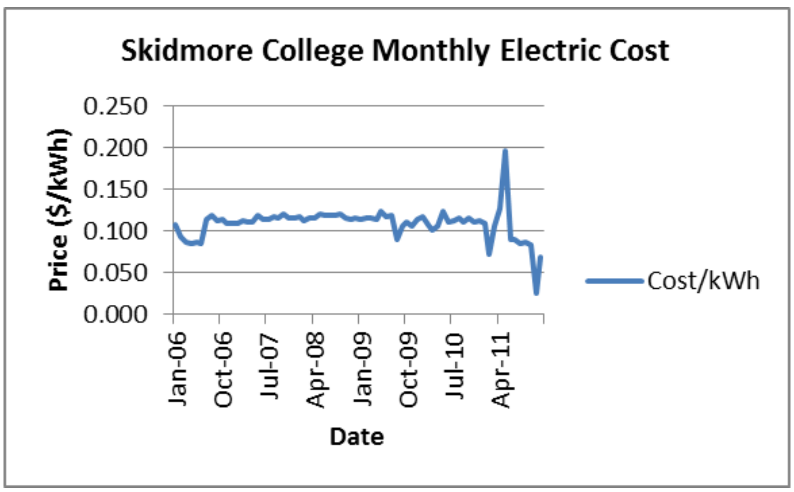


Figure 3 Electricity prices over the last 5 years

Monthly Price Fluctuations

Electricity price records for Skidmore do not demonstrate constant trends; rather they illustrate market turbulence and volatility (Figure 2). Monthly deviations from the base bid price are common, and tend to be the result of electricity price increases from high demand. Price fluctuations within a year often range within $0.05/kwh, but there have been cases of fluctuations that exceed $0.10/kWh (Ahmann 2012), therefore making the price flux greater than our current base price. The source of most electricity-price-instabilities, demand peaks, likely will become an exceedingly pressing issue in years to come as demand increases.

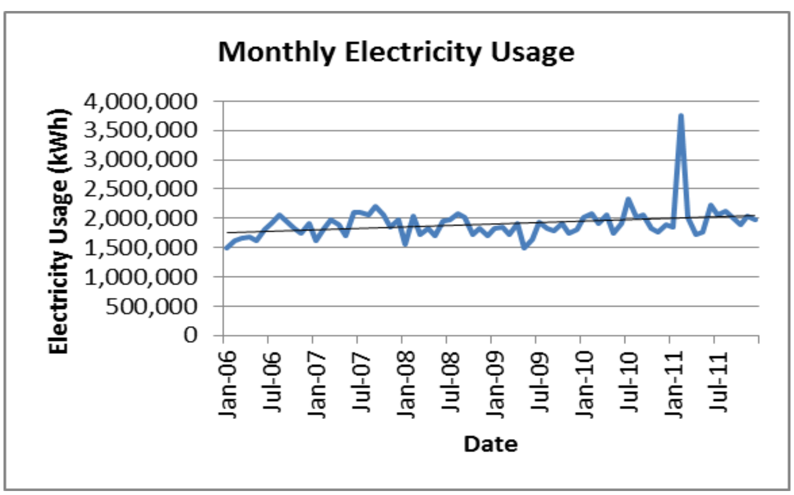


Figure 2 Skidmore College electricity consumption

Demand Increases

Skidmore's electricity consumption is a prime example of the increasing demand for electricity. The College electricity consumption is steadily increasing (Figure

3). As demand increases, the total electricity consumption will increase, the monthly price of electricity likely will increase because of the high demand surplus charges. Renewable energy options, such as solar, however, provide a consistent annual payback and supply, and can buffer peak demand spikes, thus preventing peak demand prices.

Transmission Costs

An additional consideration to account for in electricity pricing is that $0.04/kWh out of the current base price of $0.091/kWh for electricity comes from transmission costs, while the other $0.05/kWh paid is for the supply costs. After the initial installation costs, solar provides an essentially free energy source, eliminating transmission and supply costs.

Intangible benefits

In addition to the economic considerations, there are valuable intangible benefits that can result from a solar installation, which are not accounted for in monetary variables.

Demonstration of Clean Energy Commitment

A solar installation on the Skidmore College campus would exemplify and illustrate the College's commitment to clean energy. Because many of our Peer and Aspirants are already underway with solar projects on their own respective campuses, a solar installation on Skidmore College's campus would demonstrate a comparable commitment on our part, to students and community members alike. As clean energy becomes a more prevelant issue in the media, upholding this standard will become increasingly essential to the College's continued success. Additionally, as clean energy gains a foothold in the popular media, prospective students have, and will continue to, turn their attention to colleges' clean energy commitments as criteria for their college selection process. In this regard, it is crucial that Skidmore illustrates its clean energy commitment in order to maintain a competitive edge among comparable colleges. A solar installation would be a visible, outstanding demonstration of such a commitment.

Education Benefits

A solar installation could serve as an education tool on campus. The Environmental Studies Program at Skidmore offers several class that would benefit from being able to study and explore a solar installation, additionally other classes throughout the curriculum could study the installation. Further, Skidmore could offer tours and information about the solar installation to local schools and community groups. This type of community engagement would strengthen Skidmore's relationship with Saratoga Springs and demonstrate the College's commitment to serving as an education hub.

The Scenario Summaries

In considering the technological, economic and intangible considerations of a solar installation at Skidmore College, our comprehensive summaries of the feasibility of each Scenario is as follows:

Scenario 1

While the larger-scale solar installation on the Williamson Sports Center has potential benefits, particularly as an exhibition of outstanding renewable energy implementation due to its sheer size, the current feasibility for such an installation is disputable.

In terms of technological feasibility, the biggest concern is for the roof load threshold and similarly the type of racking to be used. These concerns would need to be addressed prior to further installation efforts.

The economic options for this scenario, because of the larger scale of the system, would likely require a third-party investor to assist in paying the upfront costs. A PPA could procure the capital and stability necessary to make this kind of system economically feasible, but an intensive PPA selection process would be crucial for Skidmore and the investor. The concerns of the roof weight threshold may complicate finding a willing and able investor. If Skidmore could not find a strong investor for the Sports Center this proposal should be shelved until the Sports Center has further renovations.

This installation would maximize the intangible benefits. Larger solar projects gain the most attention from funders (Elphick 2012), provide the most AC output (adding to the overall percentage of energy gleaned from renewable energy sources on campus), and have the greatest visibility, therefore, it would provide a clear demonstration of the College's commitment to environmental and clean energy initiatives.

Scenario 2

The technological feasibility of this scenario is similar to Scenario 1. As such, the biggest concerns for technological feasibility include the roof integrity and racking method.

In terms of the affordability, this scenario qualifies for the PON 2112 grant, for which the Scenario 1 is too big. The grant funding would bring down the payback period of the project, thus making the economic feasibility more attractive. The payback period for this scenario would still be 29 years however, which is longer than the ideal payback for Skidmore, therefore this scenario poses some affordability problems.

Despite the smaller size of Scenario 2, the application of solar in a central, visible and public location on campus would still be an exemplary demonstration of the College's clean energy commitment, thus making the school more appealing to prospective students as environmentalism becomes increasingly part of social consciousness and school selection processes.

Scenario 3

The potential installation at the Stables presents a unique situation in that the new construction would provide an opportunity for the new roof to be designed to specifically accommodate solar. By considering solar in the construction process and design, the potential output and overall effectiveness of the solar array could be maximized, thus maximizing economic return as well.

The new construction also enables this scenario to qualify for another state grant, the New Construction Program, which provides site-specific funding for energy efficiency construction. This funding source, in conjunction with PON 2112, would make this project even more economically feasible, providing the shortest payback period of all the scenarios.

Although the Van Lennep Riding Center is not on the main campus, a solar installation would clearly serve to demonstrate the College's commitment to clean energy, and could nonetheless be included in admissions advertising and College energy initiative statements. Furthermore, because of inter-school, community interactions with the building (horseback riding lessons and horse shows), and the adjacent public road (Daniels Road), the solar installation still would be sufficiently, publically, visible.

Conclusion

In considering the feasibility for the three solar scenarios, our technological, structural and economic analyses demonstrate that Scenario 3, a solar installation at the Van Lennep Riding Center, is the most feasible scenarios for future solar installation considerations. It is necessary to acknowledge that none of the proposed scenarios present the ideal payback periods Skidmore has strived for in the past. However, Scenario 3 is still a very attractive proposal and demonstrates that a decision about renewable energy on campus has to look beyond the monetary rewards. Solar at Skidmore would create intangible benefits while helping Skidmore remain current with the trends of its Peers and Aspirants. Further, with the grants available could reduce the installation cost by up to 70% and Skidmore could pay less than thirty-thousand dollars.

Although the Sports Center location (Scenarios 1 and 2) could potentially support a much larger installation, the uncertainty of the roof integrity and lack of federal funding for non-profit organizations wishing to develop larger solar projects, makes this site less feasible for Skidmore, especially without third-party funders. With timely consideration and application of available grant funds, the Stables would provide the best option for an inaugural solar project at Skidmore College.

Appendix A: U.S. energy production, generation and price trends within the last decade

Production: Figure 4 illustrates the resources used in US Primary Production since 1949.

Generation: Figures 5 and 6 illustrate the recent decline in the domestic rate of net electricity production. It is important to note that while net energy production seems to be increasing (Figure 5), the relative growth rate has declined (Figure 6). Figure 6 presents the real net production in terms of 2001 values, therefore demonstrating the decline in current net productions relative to previous production. Figure 6 demonstrates a decline in production in 2008 and another moderate decline currently. These decreases suggest instability in the United States' energy production.

Price Trends: Figure 7 illustrates the trend in electricity price since 2001. Clearly, electricity prices have steadily increased within the last decade.

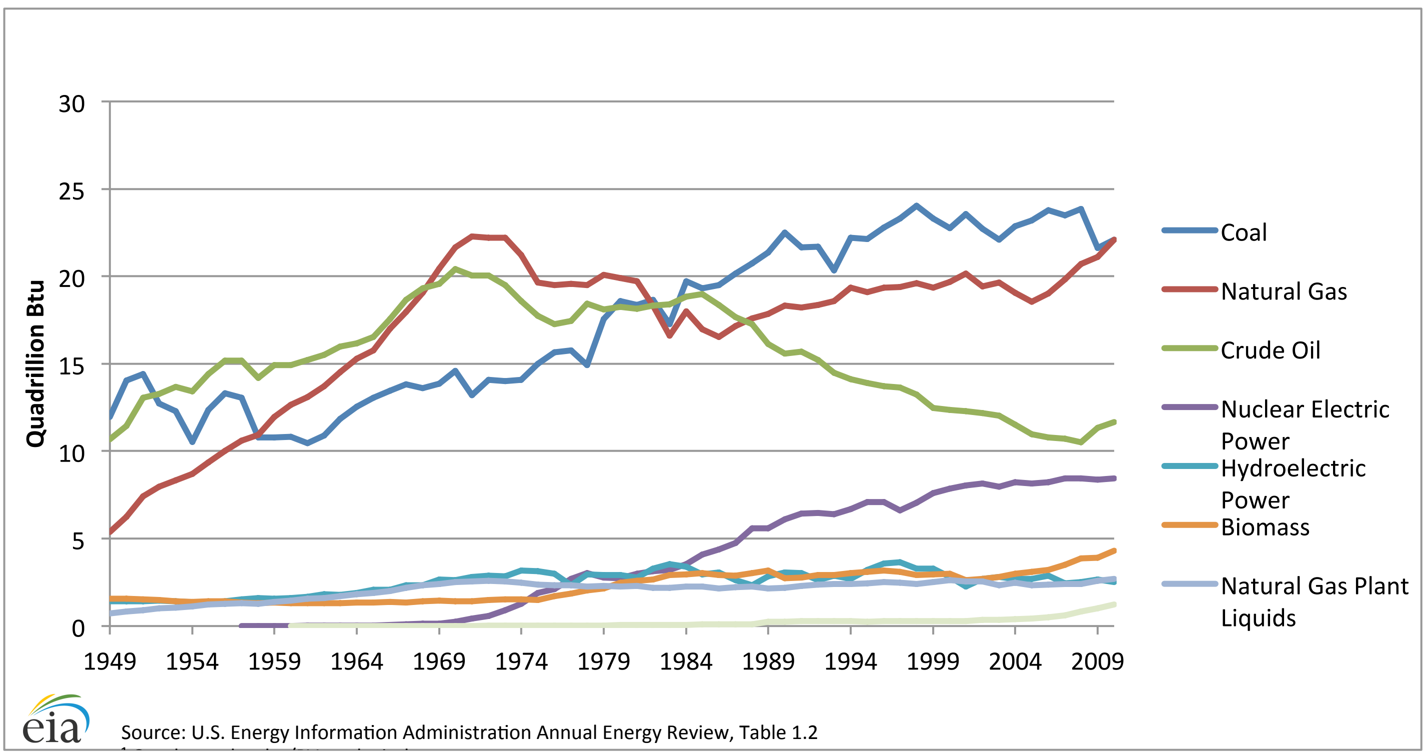


Figure 4 US Primary Production By Major Source, 1948-2010

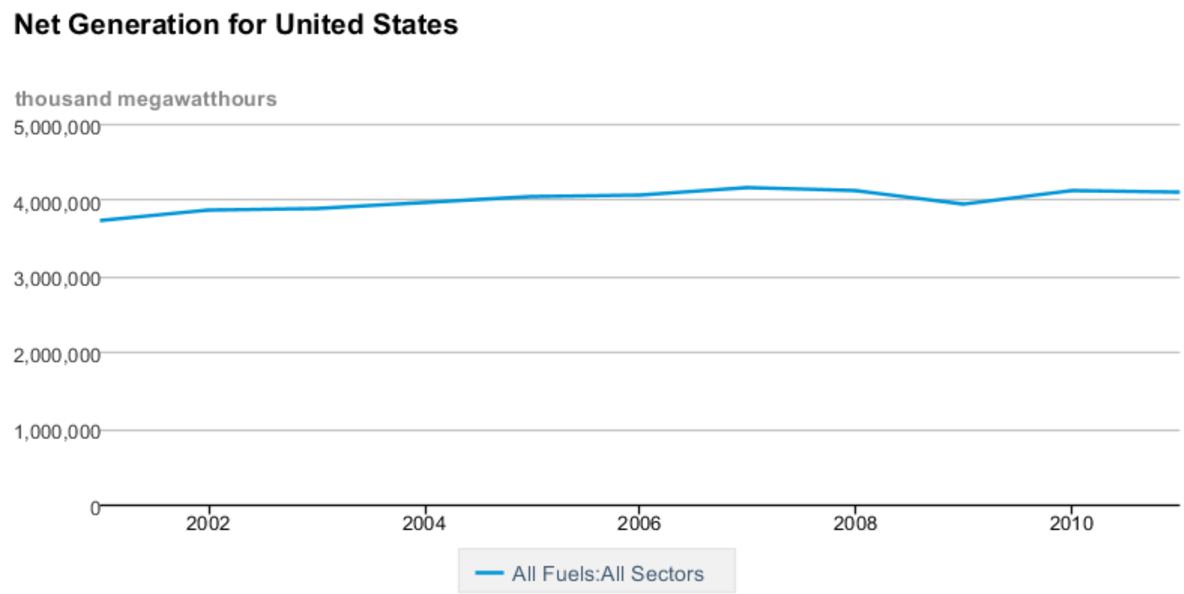


Figure 5 Domestic Net Energy Production

Source: U.S. Energy Information Administration

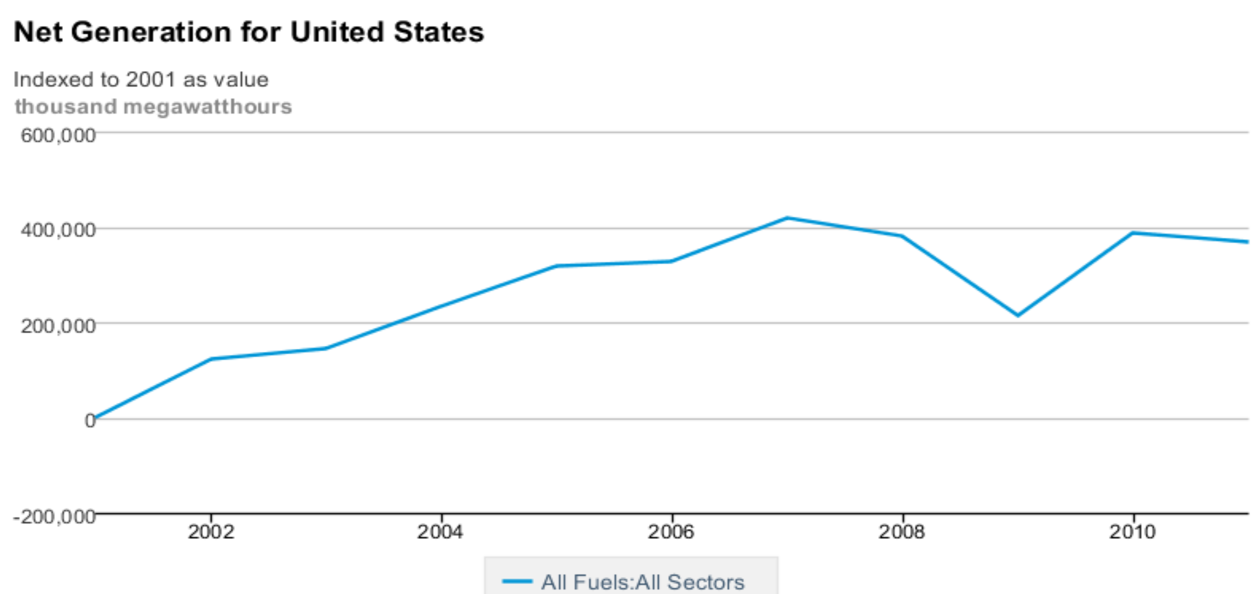


Figure 6 Domestic Net Energy Production in terms of 2001 production

Source: U.S. Energy Information Administration

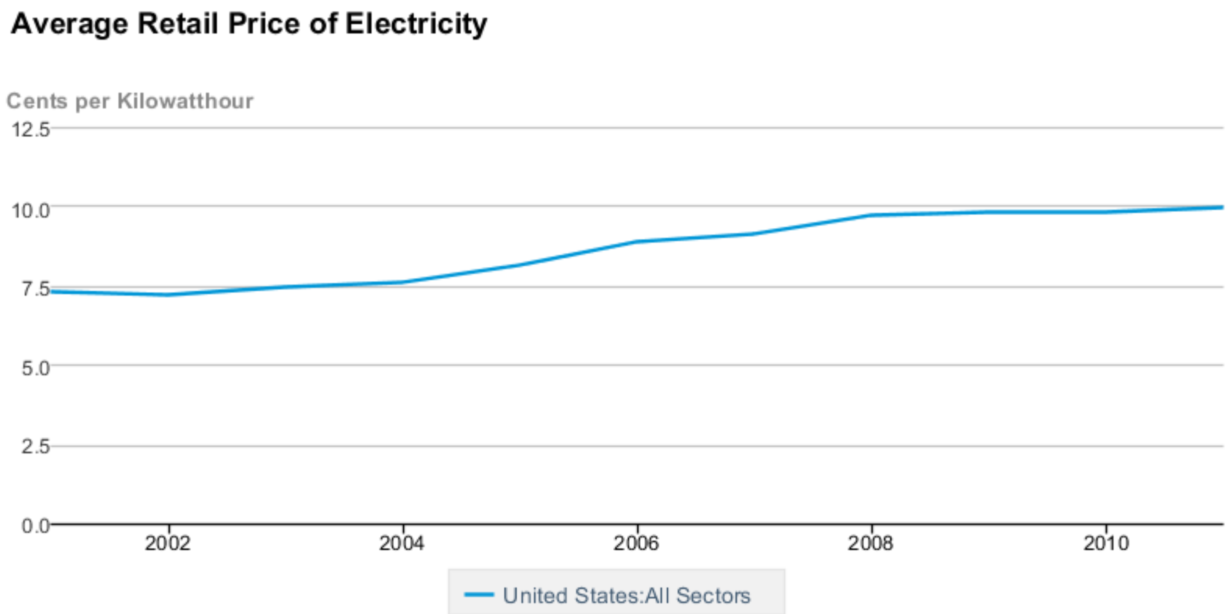


Figure 7 US Average Retail Price of Electricity, 2011-2011

Source: U.S. Energy Information Administration

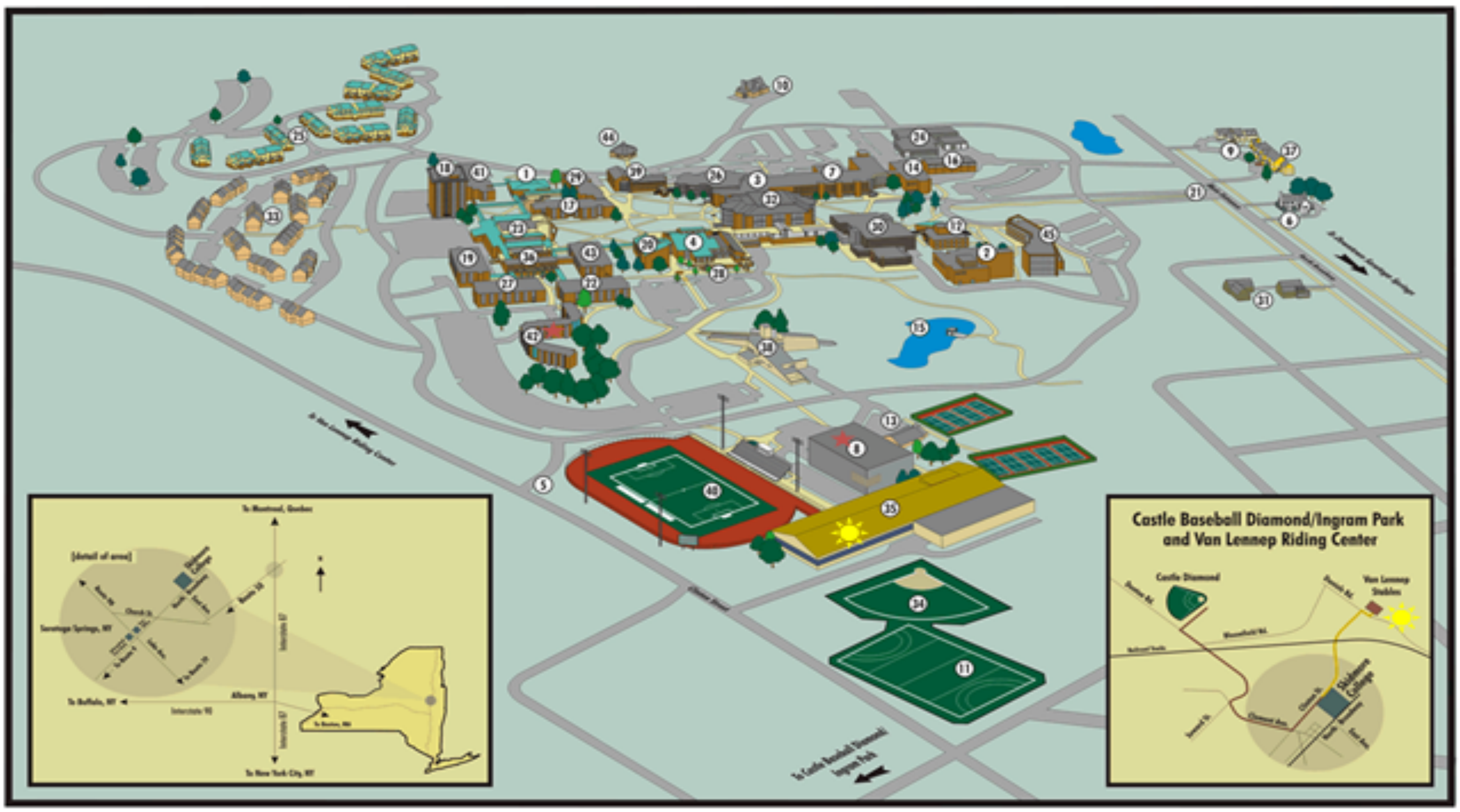
Appendix B: Skidmore College Campus Map

Indicates proposed Solar Site

Indicates proposed site for geothermal

SKIDMORE COLLEGE

Skidmore College
815 North Broadway - Saratoga Springs, NY 12866
518-580-5000 - www.skidmore.edu



1. Barrett Center
2. Bernhard Theater
3. Bolton Hall
4. Case Center
5. Clinton Street Entrance
6. Colton Alumni Welcome Center
7. Dana Science Center
8. Dance Center
9. Eissner Admissions Center
10. Falstaff's
11. Field Hockey Field
12. Filene Music Building
13. Greenberg Child Care Center
14. Harder Hall
15. Haupt Pond/South Park
16. Hoge Heating Plant
17. Howe Hall
18. Jonsson Tower
19. Kimball Hall
20. Ladd Hall
21. Main Entrance
22. McClellan Hall
23. Murray - Aikins Dining Hall
24. North Hall
25. Northwoods Village - Moore Commons
26. Palamountain Hall
27. Penfield Hall
28. Porter Plaza
29. Rounds Hall
30. Saisselin Art Building
31. Scribner House
32. Scribner Library
33. Scribner Village Apartments
34. Softball Diamond
35. Sports and Recreation Center
36. Starbuck Center
37. Surrey Williamson Inn
38. Tang Teaching Museum and Art Gallery
39. Tisch Learning Center
40. Wachenheim Field
41. Wait Hall
42. Wiecking Hall
43. Wilmarth Hall
44. Wilson Memorial Chapel
45. Arthur Zankel Music Center

Appendix C: *Methodological Considerations for Technological Feasibility*

We worked with Professor Rodney Wiltshere, adjunct professor teaching the ES251B class titled Energy Engineering. Professor Wiltshere helped us to develop the technical feasibility portion of our analysis by generating a 'site report' using the *Solar Path Finder Assistant* computer program, version 4.1.40.0. The latitude and longitude coordinates, as well as the roof tilt, and azimuth angle of the roof, were used to generate site-specific analysis for each scenario, and are as follows:

Scenario 1 and 2

Latitude/ Longitude: (43.076, -73.775)

Tilt: 15 degrees

Azimuth: 170 degrees

Scenario 3

Latitude/ Longitude: (43.076, -73.775)

Tilt: 20 degrees

Azimuth: 165 degrees

Geographic Imagery System (GIS) programs such as Google Map and ArcMap 10 were used to find the total area of the potential solar installation site, so that the number of solar panels of the total system can be estimated.

A panel make and model was selected in order to analyze the DC rate per panel, panel count, and total system size. For our analysis, Quantum Technologies' (an American manufacturer) solar model QS 23W/60-156 SP 2BB was the panel from which we based our analysis. Similarly, an inverter make and model were selected to provide a base for our site analysis. We used Emphase Energy's M215-60-SIE-S2x inverter model, which is a micro-inverter. A micro-inverter connects to each individual panel in the system, as opposed to a string inverter system, which has a single inverter linking many panels. Micro-inverters enable each panel to be monitored separately, so if there is a problem with one panel or inverter, it can be fixed or replaced as a single unit. The derate factor of the inverter was also included in our site analysis. The derate factor for the inverter model we used was 0.960, which accounts for the innate efficiency of the inverter.

Annual solar insolation averages for the site's coordinate location, and the site owner's cost of electricity are additional variables included the solar site report program to produce the solar installation's potential electric output and payback period. The Solar Path Finder Report generates results using the site-specific variable inputs, and compares the inputted values to the ideal scenario for maximum solar potential. For example, a fixed solar installation would be installed at the same latitude as the site coordinates for maximum solar potential.

Inferred constants:
Base cost of solar installation (panel price, inverter price and labor): $3.60/W
Panel Make and Model: Quantum Technologies, QS 230W/60-156 SP 2BB
DC Rate per panel: 230W
Inverter Make and Model: Emphase Energy, M215-60-SIE-S2x
Derate Method and Factor: Inverter Derate Only, 0.960
GHG Emission per kWh: 6.8956×10^{-4} metric tons CO_2 / kWh (US EPA, 2012)

Appendix D: Peer and Aspirant Solar Projects on Campus

School	Project	Details	Contact
Bowdoin*	Schwartz Outdoor Leadership Center (installation 2009)	Used a grant from the Bingham Foundation and support from Bowdoin class of 2008.	Keisha Payson cpayson@bowdoin.edu http://www.bowdoin.edu/sustainability/campus-initiatives/index.shtml
	Dining Hall Solar Thermal (installation 2010)	24 glazed flat plate solar (960 ft^2 solar thermal array, used a $50,000 grant from ARRA. Doubled the solar thermal on the dining hall in 2011.Awarded a second $50,000 grant from ARRA for this.	
Middlebury*	Two different solar thermal systems at a student house	30 efficient solar panels that will produce an estimated 7930 KWh of AC energy annually in Vermont	Nan Jenks-Jay jenksjay@middlebury.edu http://www.middlebury.edu/sustainability/
Wesleyan*	Freeman Athletic Center Roof and Parking Lot (completed Feb.2012)	200 kW PV panels, funded by a grant	Peter Staye pstaye@wesleyan.edu http://www.wesleyan.edu/sustainability/
	Admissions Building (installation 2008)	64 EPV 42-watt solar modules, set up as a Power Purchase Agreement	
Connecticut College	Park Residence (installed during the 1999 renovation)	10 kW array of solar panels on the roof of the Park residence hall, this generates 10% of the building's need. Electricity from the panels is used to offset the power required by the boiler plant that was installed the same year	Josh Stoffel jstoffel@conncoll.edu http://www.conncoll.edu/green/greenliving/7440.htm
Dickinson College	College Farm	Installed 70 kW of PV arrays	Jenn Halpin halpinj@dickinson.edu http://blogs.dickinson.edu/farm/learn/solar/
Franklin and Marshall-	Sustainability House and the Hackman Physical Science Laboratories	2011 became the first retail customer of the Keystone Solar Project, community	Sarah Dawson sarah.dawson@fandm.edu http://www.fandm.edu/bey

		energy project that will be completed next year. The 6-megawatt, ground-mounted solar farm will produce 7,500 megawatt hours of electricity annually — the equivalent of powering 950 homes each year.	ondgreen/topics/energy-and-greenhouse-gases
Oberlin	Adam Joseph Lewis Center for Environmental Studies and the adjacent parking pavilion (installed 2006).	A 159 kW PV, largest PV array in Ohio.	Colin Koffel colin.koffel@oberlin.edu http://www.oberlin.edu/sustainability/portfolio/energy.html

*Indicates Aspirant School

Complete List of Skidmore's Peer and Aspirant Schools

Aspirant
Bowdoin College
Colby College
Middlebury
Haverford College
Wesleyan College

Peer
Bard College
Bates College
Colgate University
Connecticut College
Dickinson College
Franklin & Marshall College
Hamilton College
Kenyon College
Oberlin College
Sarah Lawrence College
St Lawrence University
Trinity College
Vassar College
Wheaton College

Appendix E: List of Grant Resources

Below is a comprehensive list of grant searching resources. All of these websites were used in our financial study and provide useful, current information on renewable energy requirements and funding.

NYSERDA- http://www.nyserda.ny.gov/

NYSERDA is the online resource of the New York State Energy Research and Development Authority. NYSERDA provides many online resources for education purposes, employment opportunities, energy efforts specific to the state of NY and many funding opportunities. NYSERDA is a useful resource for grant research considering the concentration of federal loans they administer. Grants can be found under the "Funding Opportunities" button.

DSIRE- http://www.dsireusa.org/

DSIRE is the Database of State Incentives for Renewables and Efficiency. DSIRE is a database for the United States that provides a comprehensive list of state, local and federal incentives for renewable energy initiatives. Since DSIRE compiles incentives by state, one can quickly access grant opportunities for any state. Further, these opportunities are focused on renewable energy which is useful when looking for solar specific grants.

Grants.gov- http://grants.gov/

Grants.gov is the official US government online resource for non-profit grants. Grants.gov provides several attractive features that are useful for grant research. One can search for grants by agency, such as Environmental Protection Agency or the Department of Energy. Or one can search by keyword, this is especially useful for solar grants, because this search option will provide results from all government agencies.

EPA- http://epa.gov/

The Environmental Protection Agency's website is a useful resource for education about the current energy problems, and the political polices in place. Further, http://www.epa.gov/greenpower/ focuses specifically on green energy options. This site provides information about both the technology and economics of renewable energy sources. There is also the option to select a specific state to learn more about area-specific green power.

AASHEE- http://www.aashe.org/

The Association for the Advancement of Sustainability in Higher Education (AASHE) is a good resource for all college sustainability efforts. AASHE acts as a forum and networking vehicle for sustainability initiatives across American universities and colleges. AASHE also has a search engine, where one can research specific issues such as solar. These searches often result in case studies of other colleges.

Appendix F: *RECs*

When looking at renewable energy electricity there are two important numbers to look at (Figure 8). There is the electrons produced by the renewable energy, for solar this is the kilowatts per hour the solar panels produce. The second number is the renewable energy attributes. These attributes are the environmental benefits from using a renewable energy, and they are called renewable energy certificates (RECs). RECs provide a monetary value to the use of a renewable energy instead of a nonrenewable like coal or oil.

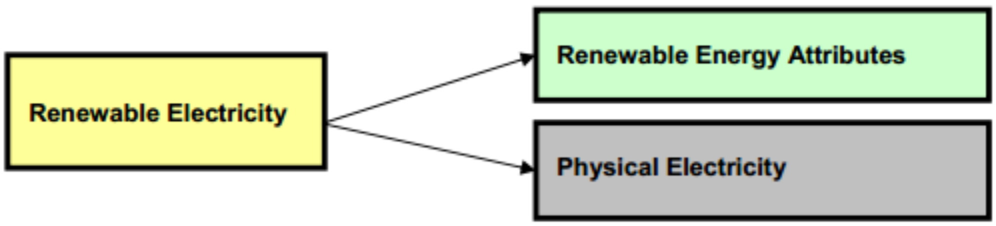


Figure 8 Renewable Energy Outputs, source http://www.nrel.gov/docs/fy08osti/41409.pdf

RECs create a competitive market for renewable energy where none-utility entities can sell RECs from their renewable energy to electricity companies. RECs are state-specific and differ in applicability and eligibility. The use of RECs can reduce the cost of RPS compliance by lowering transmission and distribution costs, while also providing access to a larger quantity of resource options (Cory and Swezey 2007).

It is important to note, if Skidmore were to sell RECs from solar, the School could not consider the solar electricity as an offset of their green house gas emissions because technically the purchaser of the RECs would “capture” the offsets.

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