From Roofs to Rivers: Moving the Needle on Skidmore's Sustainability Goals

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Table of Contents

Executive Summary

Increasing levels of greenhouse gases and pollutants in our atmosphere have led to individual, institutional, and governmental action, yet global temperatures continue to rise. Although it's clear fossil fuel consumption is directly linked to climate change, 83% of Skidmore's energy still comes from fossil fuels. Skidmore has committed itself to sustainability by setting goals in five areas: energy, food, lands and grounds, waste, and engagement. Our research focuses on addressing the energy and engagement goals. Our research has culminated in a feasibility study in which we identify renewable energy projects that will help Skidmore address its energy and engagement goals.

The first component of our findings portfolio is Solar on Campus. With this project, we propose that Skidmore harness the potential it has in all of its rooftops by installing solar panels on its main campus. We conducted a feasibility analysis to determine how this could be done, and in doing so we learned that Skidmore could either enter into a Power Purchase Agreement (PPA), or a lease agreement. In both cases, Skidmore would not own, operate, or maintain the panels, but rather would be a third party leasing its rooftop space to a solar provider, who would financially compensate Skidmore in return. We recommend Skidmore opt for the lease agreement, mainly because it would involve less uncertainty regarding Skidmore's compensation. With this option, Skidmore would be projected to net $49,488 in the first year and $1,264,160 over 20 years. We propose that Skidmore use this revenue to start a "Green REC Fund," which would be used to purchase RECs that would allow Skidmore to claim renewable energy use and GHG emissions reductions. With the first year revenue from the lease, Skidmore could purchase 2,206 RECs, which would give Skidmore a 9.2% increase in electricity from renewable sources, and a 5.2% reduction in GHG emissions.

The second component is a subscription to a utility-sponsored Community shared solar project. This project would involve no investment on behalf of Skidmore, is available for purchase immediately, and would lower the price we pay per kWh on Skidmore's auxiliary electricity meters by 10%. We determined that, if implemented, this would save Skidmore $9,350 annually. If these saving were reinvested into the purchasing of RECs, the amount of energy Skidmore receives from renewable sources would increase by 2%, and our overall GHG emissions would be lowered by 1%.

The third component is a proposed alternative student housing option in the form of tiny homes. As the average American house size continues to grow, so too does their environmental footprint and GHG emissions. Tiny homes, in part, are a response to over consumption and global climate change through sustainable living and practices. We propose that Skidmore College develop a course in which students learn how to design tiny homes in the first semester and build them in the second. Students could then use their knowledge to teach their peers and Saratoga community members about the benefits of sustainable living. We estimate that tiny homes could be built by students for roughly $30,000. If Skidmore charged the same price to live in tiny homes as a single occupancy residence hall, the tiny homes would have a payback period of just over three years. These tiny homes will primarily address the engagement component of

Skidmore's Campus Sustainability Plan by allowing students to live in direct contact with solar power.

For our final component, we recommend that Skidmore look to hydropower. We worked with New England Hydropower, a Massachusetts-based hydropower company that specializes in restoring old sites with Archimedes Screw technology, and identified a potential site situated on an old canal system in Upstate New York. The project, which is projected to have a 200 kW nameplate capacity, represents a profile of an existing site ready for development. We believe that this project, or one like it, would constitute a great addition to Skidmore's renewable energy portfolio.

Together, the Solar on Campus and Community Shared Solar projects would result in a 11.2% total increase in energy from renewable sources and a 5.2% reduction in greenhouse gas emissions if the revenue and savings were used to purchase RECs. With the additional power that could be generated from a future hydropower facility, Skidmore has the potential to achieve its energy goals.

Introduction

Humans have understood the concept of the greenhouse effect for at least a century, but it wasn't until 1990 that the Intergovernmental Panel on Climate Change's (IPCC) First Assessment Report affirmed that global warming is a serious threat (Chasek et. al, 2017). Since then, four additional reports have been published, with the most recent report concluding that "human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history." It also stated that anthropogenic greenhouse gas emissions are "extremely likely to have been the dominant cause of observed warming through the mid-20th century" (IPCC, 2014). These claims are evidenced by observed increases in temperature in the atmosphere and the oceans that correlate tightly with historical anthropogenic greenhouse gas (GHG) emissions. Currently, the concentration of CO_2 equivalent GHGs in the atmosphere is around 405 parts per million (ppm), and the IPCC contends that keeping this concentration at 450 ppm or lower by 2100 will "likely" maintain warming below 2°C over the 21st century relative to pre-industrial levels (IPCC, 2014). Even if humans do manage to get our emissions under control in a timely manner, the IPCC report found that "many impacts of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases" (IPCC, 2014). The longevity of GHGs in the atmosphere means that we could potentially have already "locked in" a certain amount of change in the global climate, regardless of action that might be taken regarding GHG emissions. What this means for the global community is that action must be taken immediately to reduce GHG emissions in an effort to minimize the impacts of climate change, as we can see now it is unavoidable.

International Efforts

It is clear that the GHG emissions being released through our energy production and consumption are directly linked to climate change, yet internationally 83% of our energy still comes from fossil fuel-based sources (UN, 2017). With global energy consumption rates set to increase by 28% from 2015 to 2040, a 17% share for renewable energy will almost certainly be insufficient to stave off the worst effects of climate change (IEO, 2017). As awareness of our needs for increased energy production in the near future grows, so do investments being made in the global production capacity of renewable energy. For example, in the European Union, renewable energies account for 80% of the new energy production technologies being installed to improve the net capacity of the grid (WEO, 2017).

There are five major energy consuming sectors in the United States: electric power generation, transportation, industry, residential, and commercial. Each sector's share of total primary energy consumption for 2017 breaks down as follows: electric power accounts for 38.1%; transportation 28.8%; industrial 22.4%; residential 6.2%; and commercial 4.5% (EIA, 2018). Patterns of fuel usage vary widely within these sectors, however. For example, petroleum provides about 92% of the energy used for transportation, but only 1% of the energy used to generate electricity (EIA, 2018). While the usage of these fuels changes depending on the sector, one fact remains consistent: 80% of the United States' energy production mix comes from fossil fuel sources (EIA, 2018).

In the face of global climate change, the reduction of greenhouse gas emissions and the promotion of renewable energy technologies will be paramount to ensuring a sustainable future. A number of renewable energy sources, most notably wind and solar, are quickly reaching price and performance parity on and off the grid. In the face of opposition from competing industries, renewable energy is proving able to meet demand for reliable, affordable, and environmentally sustainable energy. Having only recently been recognized as a “mainstream” energy source, renewables are fast becoming preferred, and demand for them is increasing.

Action Being Taken

Across the globe, people are fighting for the implementation of renewable energies in an effort to take action on climate change. The fight against climate change is happening on the individual level (e.g. people installing renewables on their homes) and, more importantly, on a collective level. Businesses are increasingly deciding to make their business practices more sustainable in various ways. For example, the software company Adobe aimed to achieve a 75% reduction—from 2000 levels—in its GHG emissions by 2015, and it used renewable energy technologies, including solar arrays and fuel cells, to meet its goal (Best Practices in Sustainability, 2014). Along with businesses, individual communities are taking action to reduce their GHG emissions. For instance, 20 states and 50 cities—in an initiative dubbed “America’s Pledge on Climate”—have committed to the goals outlined in the Paris Agreement despite the fact that the US is in the process of pulling out of the agreement (America’s Pledge on Climate, 2018).

As centers for knowledge, progress, and innovation, colleges have also played an important role in the fight against climate change, most often by implementing energy efficiency and clean energy projects, and creating sustainability curricula and programs. When colleges engage in these kinds of activities, they do not only increase their own sustainability and serve as models for other institutions, but—arguably more importantly—they invest in the future by educating their students and encouraging them to become leaders and activists genuinely interested in solving the problem of climate change.

Each academic institution makes individual efforts to bolster their own sustainability, and some have been extremely successful with their initiatives. For example, American University pledged to achieve carbon neutrality by 2020 in 2010, and in April of 2018 announced that the goal had been achieved two years earlier than expected (American University, 2018). Another sustainable initiative being implemented by many institutions is the process of monetary divestment. Put simply, divestment is the opposite of investment, meaning that investors get rid of stocks, bonds, and investment funds that might be unethical or morally ambiguous, such as investments in fracking technologies (Fossil Free: Divestment, 2018).

More and more universities and colleges are committing to sustainability, and it is becoming increasingly more of a concern to prospective students and parents. Of 11,000 teens and parents surveyed by the Princeton Review, 63% of respondents said information about a college's commitment to the environment would influence their decision to apply or attend the school (The Princeton Review, 2018). This indicates sustainability is an increasingly important initiative to the general population and opens the door for new projects for Skidmore to capitalize on.

Actions at Skidmore

Skidmore College is committed to sustainability, as exemplified by that fact that it is currently one of the Princeton Review's top 50 "Green Colleges," which are selected based on academic offerings, campus policies, initiatives, activities and preparation for students. Skidmore is ranked 34th overall, behind Colby College (#20) and Middlebury College (#24) (The

Princeton Review, 2019). Skidmore's commitment is also reflected in its Campus Sustainability Plan. The Plan, published in 2015 and setting goals to achieve by 2025, states that Goal 1 of Skidmore's Campus Sustainability Plan is to obtain 60% of the College's electricity from renewable sources by 2025 (this does not include energy generated by nuclear power). Currently, 40% of Skidmore's electricity demand is satisfied by renewable sources (Figure x?), so a 20% increase would constitute a successfully met goal. While this goal may seem simple and straightforward, net metering regulations, rapidly changing energy markets, and potential growth at Skidmore make this a challenging, but achievable goal (Skidmore Campus Sustainability Plan, 2015). Skidmore also committed to reducing its GHG emissions by 75% from 2000 levels by 2025, and has made significant progress towards this goal. In 2013, a GHG inventory showed a 48% reduction in Skidmore's GHG emissions. A number of energy efficiency projects have been implemented to help reach this goal, including: LED lighting in Zankel music hall, a fleet of fuel-efficient vehicles, electric vehicle charging stations, and cold water wash only washing machines.

In 2014, Skidmore completed development of its most recent renewable energy project— a photovoltaic solar array that generates ~2.6 million kilowatt hours of electricity annually (Skidmore College, 2014). The energy provided by this project met about 10.5% of Skidmore's electricity needs in 2018. Also in 2014, Skidmore College partnered with Gravity Renewables to revitalize a small hydroelectric dam located on Chittenden Falls, NY with the potential to generate approximately 18% of Skidmore's electricity needs. This was the first remote net-metered small hydro project in the United States. In the 2018 school year, the hydrodam provided approximately 10.5% of Skidmore's electricity (CITE). To ensure the realization of its energy goals, Skidmore will need to continue to introduce more renewable energy projects.

Methods

With this research opportunity, we chose to evaluate and recommend a suite of potentially viable projects for the College to consider. In exploring this variety of projects, we completed financial analyses and feasibility studies for various renewable energy technologies, as well as investigated current net metering and remote net metering regulations, along with the current renewable energy certificate (REC) system for the state of New York. Our methods included utility bill analysis, unstructured interviews, physical viability analysis, regional incentive evaluation, financial analysis, and GHG emissions reduction analysis. Our research also focused on ways in which Skidmore can increase its engagement opportunities for students and the

greater community. Our research culminated in a feasibility study in which we lay out four ways Skidmore can address its energy and engagement goals: solar on campus, community shared solar, alternative student housing, and future hydropower.

Constraints

Some of the most important information that our Capstone revealed was that a number of factors constrain what Skidmore has to deal with when implementing new renewable energy projects on campus. The first of these constraints is a monetary constraint. As a non-profit institution, Skidmore is unable to take advantage of tax exemptions and other incentives that solar providers can access. This makes it harder for Skidmore to profitably own and operate a renewable energy facility because it is less economically incentivized. Skidmore is also constrained by regulations. The regulations in the renewable energy market are constantly changing, making it extremely difficult to know if a potential project is viable considering all current regulations (Conrad, 2019). The final constraint has to do with electricity meters. We learned that current regulations limit the amount of renewable energy projects that can be associated with a single electricity meter through the process of remote net metering (Conrad, 2019).

Solar on Campus

Our feasibility analysis for Solar on Campus produced very promising results. As a whole, the roofs on Skidmore's campus were found to have the potential to produce up to 6 megawatts (MW) of solar energy annually. However, we learned that most rooftops on campus––for a variety of reasons—would not be effective hosts for this solar project. For instance, North Hall and Williamson Sports Center were deemed unable to support solar panels because of their prefabricated construction, which does not allow for any more weight on the roofs. Additionally, many rooftops on campus were deemed too small to be cost effective for a project of this scale. This can be explained by the fact that smaller solar installations are not as cost effective ($/area) as larger ones, and that the cost of the project increases with the number of buildings receiving installations (Conrad, 2019). On top of this, already existing solar thermal units on the roof of the Dining Hall and Penfield, Wilmarth, McClellan, and Kimball Halls take up enough space to make solar PV installations not cost effective. We also excluded Harder Hall from our analysis because, according to the Skidmore Campus Plan, it will be taken down within the next few years (Skidmore College, 2007). With this in mind, we determined the best strategy would be to include all of the viable, larger roofs, and leave out the more numerous, smaller roofs. The results of this selection process are shown in Figure 1. The selected rooftops would have a capacity of 1.9 million kilowatts (kW) and be projected to produce 2,573,389 kWh in the first year.

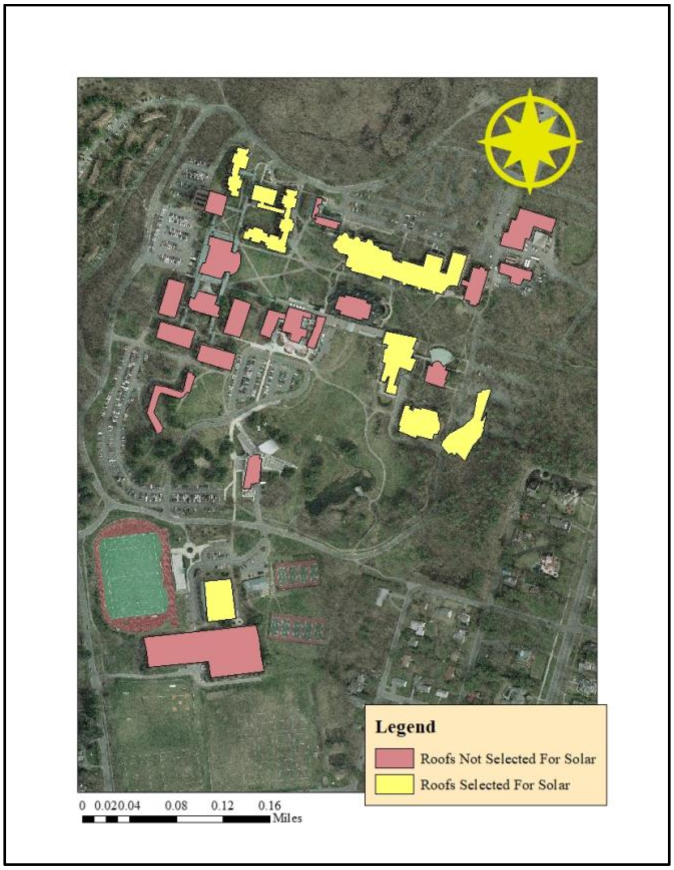

Figure 1: Map showing Skidmore campus rooftops selected for rooftop analysis.

Within the plan to put solar panels on Skidmore's roofs, there are two options for the type of agreement that Skidmore could enter into: a power purchase agreement (PPA), or a lease agreement. Because Skidmore would not own the panels in either case, but would effectively be a 3rd party allowing a solar provider to use its rooftops in exchange for financial compensation, Skidmore would not be responsible for any upfront costs or consulting fees. The difference between these two options lies in the method of compensation; in a PPA, Skidmore's compensation would be tied to the solar panels' production, while in a lease agreement, Skidmore's compensation would be guaranteed regardless of the solar panels' production.

Financial analysis found that the lease agreement would generate $1,264,160 in revenue over 20 years, while the PPA-style agreement would generate $2,084,781 over the same period (Conrad, 2019). The revenue breakdown for the lease agreement is shown in Table 1, while the revenue breakdown for the PPA is shown in Table 2.

YEAR	ANNUAL REVENUE ($)	TOTAL REVENUE ($)
0	$0	$0
1	$49,488	$49,488
2	$50,725	$100,214
3	$51,994	$152,207
4	$53,293	$205,501
5	$54,626	$260,126
6	$55,991	$316,118
7	$57,391	$373,509
8	$58,826	$432,335
9	$60,297	$492,632
10	$61,804	$554,436
11	$63,349	$617,785
12	$64,933	$682,718
13	$66,556	$749,274
14	$68,220	$817,494
15	$69,926	$887,420
16	$71,674	$959,093
17	$73,466	$1,032,559
18	$75,302	$1,107,861
19	$77,185	$1,185,046
20	$79,114	$1,264,160
Total	**$1,264,160**	**$1,264,160**
Avg	**$63,208**	

Table 1: Breakdown of potential revenue generated by lease agreement (Conrad, 2019).

YEAR	SOLAR OUTPUT (kWh)	SOLAR PPA RATE ($/kWh)	SOLAR PPA PAYMENTS ($)	UTILITY COST OFFSET W/SOLAR ($/kWh)	UTILITY COST OFFSET W/SOALR TOTAL ($)	ANNUAL SAVINGS W/SOLAR ($)	TOTAL SAVINGS W/SOLAR ($)
1	2,573,389	$0.1000	$257,339	$0.1120	$288,220	$30,881	$30,881
2	2,560,522	$0.1000	$256,052	$0.1148	$293,948	$37,896	$68,776
3	2,547,719	$0.1000	$254,772	$0.1177	$299,790	$45,018	$113,795
4	2,534,981	$0.1000	$253,498	$0.1206	$305,748	$52,250	$166,045
5	2,522,306	$0.1000	$252,231	$0.1236	$311,825	$59,595	$225,640
6	2,509,694	$0.1000	$250,969	$0.1267	$318,023	$67,053	$292,693
7	2,497,146	$0.1000	$249,715	$0.1299	$324,343	$74,629	$367,322
8	2,484,660	$0.1000	$248,466	$0.1331	$330,790	$82,324	$449,646
9	2,472,237	$0.1000	$247,224	$0.1365	$337,364	$90,141	$539,786
10	2,459,876	$0.1000	$245,988	$0.1399	$344,069	$98,082	$637,868
11	2,447,576	$0.1000	$244,758	$0.1434	$350,908	$106,150	$744,018
12	2,435,338	$0.1000	$243,534	$0.1470	$357,882	$114,348	$858,366
13	2,423,162	$0.1000	$242,316	$0.1506	$364,995	$122,679	$981,045
14	2,411,046	$0.1000	$241,105	$0.1544	$372,249	$131,145	$1,112,189
15	2,398,991	$0.1000	$239,899	$0.1583	$379,648	$139,749	$1,251,938
16	2,386,996	$0.1000	$238,700	$0.1622	$387,193	$148,494	$1,400,432
17	2,375,061	$0.1000	$237,506	$0.1663	$394,889	$157,383	$1,557,814
18	2,363,185	$0.1000	$236,319	$0.1704	$402,737	$166,418	$1,724,233
19	2,351,370	$0.1000	$235,137	$0.1747	$410,741	$175,604	$1,899,837
20	2,339,613	$0.1000	$233,961	$0.1790	$418,905	$184,944	$2,084,781
21	0	$0.0000	$0	$0.0000	$0	$0	$2,084,781
22	0	$0.0000	$0	$0.0000	$0	$0	$2,084,781
23	0	$0.0000	$0	$0.0000	$0	$0	$2,084,781
24	0	$0.0000	$0	$0.0000	$0	$0	$2,084,781
25	0	$0.0000	$0	$0.0000	$0	$0	$2,084,781
Totals	**49,094,868**	**$0.1000**	**$4,909,487**	**$0.1431**	**$6,994,267**	**$2,084,781**	**$2,084,781**
Avg	**2,454,743**	**$0.1000**	**$245,474**	**$0.2044**	**$349,713**	**$104,239**	

Table 2: Full financial breakdown for PPA, showing both the factors that would determine generated revenue, and the 20-year breakdown of potential revenue (Conrad, 2019).

Unfortunately, because Skidmore would not own the panels, Skidmore would not be able to claim the environmental attributes associated with the electricity they generate. This means that Skidmore would not be able to count this electricity towards its energy goals, and in turn would not be able to count the GHG emissions reductions towards its GHG goal. This would be the case despite the fact that the panels would be installed "behind the meter," meaning we would be consuming the electricity generated by the panels. This situation would be essentially the opposite setup that Skidmore has with its Denton Road Solar Array, in which Skidmore does not receive the electricity from the panels but does receive credit for renewable energy generation and consumption.

With the revenue generated by these projects, however, Skidmore has the ability to make some progress on its goals. We recommend that Skidmore buy Tier 1 Renewable Energy Credits (RECs) to help the College reach its renewable energy and GHG emissions reduction goals.

A renewable energy facility produces two products: electricity, and the environmental benefits that come with not generating that electricity from fossil-fuel based sources. These benefits are typically packaged as RECs and can be sold separately from the energy they are derived from. One REC is derived from one megawatt hour (MWh) of generated renewable energy. In the case of this project, Skidmore will sell the rights to all future RECs up-front, on a per-installed-watt basis, effectively securing a rebate and forgoing the revenue from any future REC sales (NYSERDA, 2019). We propose that Skidmore purchase Tier 1 RECs, which, in New York State, are classified as RECs generated by a certified renewable energy generator established on or after January 1, 2015 (NYSERDA, 2019).

We propose that Skidmore start a "Green REC Fund" with the revenue generated by this project. This fund would be similar to a Green Revolving Fund but would be used to purchase Tier 1 RECs, which would help Skidmore increase its share of electricity from renewable sources and reduce its GHG emissions. With the money earned in the first year from the lease agreement ($49,488), Skidmore could purchase 2,206 Tier 1 RECs (priced at $22.43 each for 2019) (NYSERDA, 2019). If Skidmore purchased 2,206 RECs, our share of electricity from renewable sources would increase by 9.2%, and our GHG emissions would be reduced by 4.2%. Figure 2 illustrates this potential progress.

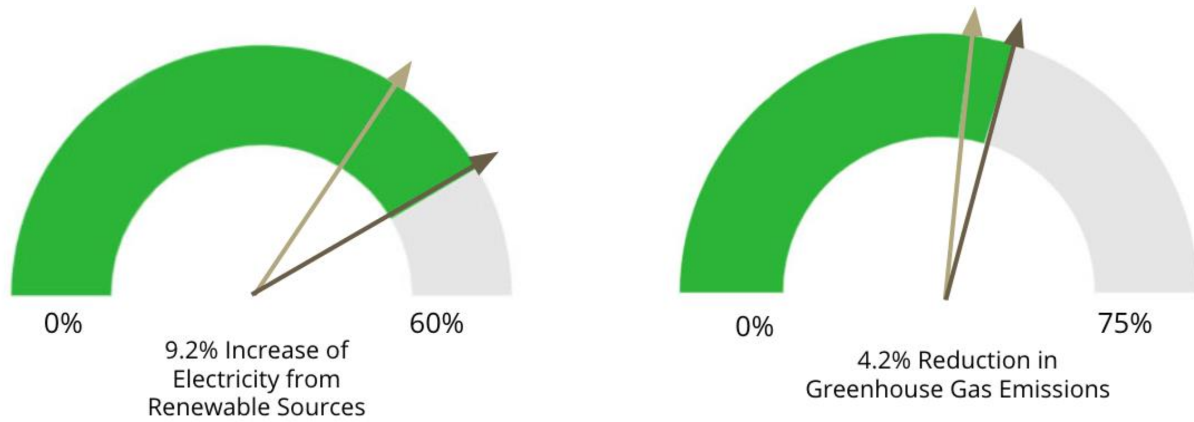

Figure 2: Dials with needles that show potential progress towards Skidmore's energy goals, accounting for progress from Solar on Campus.

Skidmore would be able to purchase 1,376 Tier 1 RECs with the money earned in the first year from the PPA-style agreement ($30,881). While the first year's revenue is less than that of the lease agreement, payments received from the PPA-style agreement would increase more rapidly over time, allowing for more RECs to be purchased over the 20 year period. Because the PPA and lease agreement options would both provide Skidmore with increasing revenue annually, Skidmore could expect to have enough revenue to purchase a comparable or even greater number of RECs each year (depending on how REC prices fluctuate), and in turn could potentially expect progress towards its goals to increase with no additional investment.

Moving forward, we recommend that Skidmore opt for the lease agreement because the projected revenue would be guaranteed, regardless of the solar panels' production. Between the lease and the PPA, the lease represents the more conservative, safer option because the lease agreement has little to no risk involved, while the PPA-style agreement would have some risk in the form of uncertainty regarding exact quantities of energy produced. It should be noted, however, that the PPA-style agreement is projected to provide Skidmore with $820,621 more than the lease agreement over 20 years. This would allow Skidmore to buy $820,621 more worth of RECs, which would help Skidmore reach its renewable energy and GHG emissions reductions goals faster.

Community Shared Solar

Our research led us to discover that we are limited by the amount of renewable energy projects that can be associated with a single electricity meter. This realization led us to investigate where the energy Skidmore uses is distributed among college-owned buildings. By examining past electrical data, we identified several buildings that we determined are potential candidates to be powered by renewable sources (Lundberg, 2019). These buildings are owned and operated by Skidmore College, but have electricity meters independent from the main campus meter. Skidmore College currently pays 14.3¢/kWh at these auxiliary meters, which is almost twice as much as the 7.6¢/kWh that they pay on the main campus meter (Lundberg, 2019). In total, these meters account for 550,000 kWh of Skidmore's electricity demand annually.

The price differential between the main and auxiliary meters represents an opportunity to save Skidmore money, that can then be invested into purchasing RECs and achieving the Campus Sustainability Goals.

One promising potential source of renewable energy, which is currently growing in popularity and accessibility, is Community Shared Solar (CSS). We were initially introduced to the concept of CSS as a potential option for Skidmore by a feasibility study undertaken by a Skidmore College Environmental Studies and Sciences Capstone team in 2018. This capstone describes CSS as "a rapidly growing form of delivering renewable energy in deregulated energy markets throughout the United States that allows for residential and small business customers to acquire shares of solar energy and receive credits or savings on monthly electric bills" (Brown & Hoffmann, 2018, 4). The results of their analysis found that CSS is a viable option in Saratoga County because "replicable models are feasible, financial incentives are increasing, land parcels such as brownfields are available for repurposing, and community interest is strong." (Brown & Hoffmann, 2018, 4). Their research culminated in the recommendation of an utility-sponsored model and was a basis from which we developed further. Figure 3 shows results of a survey they conducted exploring interest in receiving renewable energy among Saratoga Springs community members.

Our analysis focuses directly on the economic feasibility of having the 550,000 kWh of demand on Skidmore College's auxiliary meters be powered by CSS. This analysis compares the benefits and uncertainty associated with investing in the construction of a new CSS installation and subscribing to an existing CSS site.

The first option we identified for Skidmore involves investing in the construction and operation of a new CSS project in our area. As the owners and financial backbone of this potential project, Skidmore would have the ability to potentially lower current electricity prices on these auxiliary meters to as low as 7.6¢/kWh (Curry, 2019). This would be possible because solar companies typically sell solar credits for 9¢/kWh, so with commitments from community members who would pay 11¢/kWh (which would still be significantly lower than the average 14.3¢/kWh currently paid by Saratoga Springs residents), we will likely be able to reach a price point near 7.6¢/kWh for Skidmore.

If Skidmore were able achieve this goal, it would represent 6.4¢ of savings for each of the 550,000 kWh used by these buildings annually. This would equate to a savings of $35,200/year in electricity expenses. These savings are laid out in Table 3. Similar to the process described in the rooftop solar section, the money saved in this scenario would go into a Green REC Fund, and would be used to buy RECs in order to help Skidmore achieve their energy goals. With this $35,200/year savings, Skidmore could buy 1,642 RECs, which would offset 1,642 MWh of our electricity usage. This reduction would bring Skidmore to a 6.8% increase in the production of electricity from renewable sources. This would also cause a reduction in our carbon emissions of 297 MT, which is equal to a 3.1% reduction in overall carbon emissions from 2000 levels.

Year	Annual Electricity Demand (kWh)	Electricity Rate ($/kWh)	Annual Electricity Cost ($)	Annual Savings with CSS ($)	Total Compounded Savings with CSS ($)
Current	550,000	.143	78,650		
1	550,000	.076	41,800	35,200	35,200
2	550,000	.076	41,800	35,200	70,400
3	550,000	.076	41,800	35,200	105,600
4	550,000	.076	41,800	35,200	140,800
5	550,000	.076	41,800	35,200	176,000
...20					704,000

Table 3: Potential savings from a CSS investment option. These savings will likely end up helping Skidmore pay back its initial investment in this project.

However, there are certain risks associated with the uncertainty of this project. If Skidmore undertook this project, it would be difficult to say how long the payback period would be, because as of now, it is unknown what a potential investment would have to be to initiate the construction of a CSS project. Furthermore, there is uncertainty about where this potential array would be located, even if it was invested in. Finally, one of the most important things to consider about this type of investment is that in order for the project to achieve the predicted return on investment, it would require participation from the community. As you can see in the Figure below, a large portion of Saratoga Springs residents are either interested or very interested in having electricity from renewable sources at their homes. Even when considering this expressed interest, however, there is still a fair amount of uncertainty involved because all that is known is public interest. Community members have yet to sign on to the program, meaning we can't know if enough people will sign on to make it economically feasible until the site is already in operation.

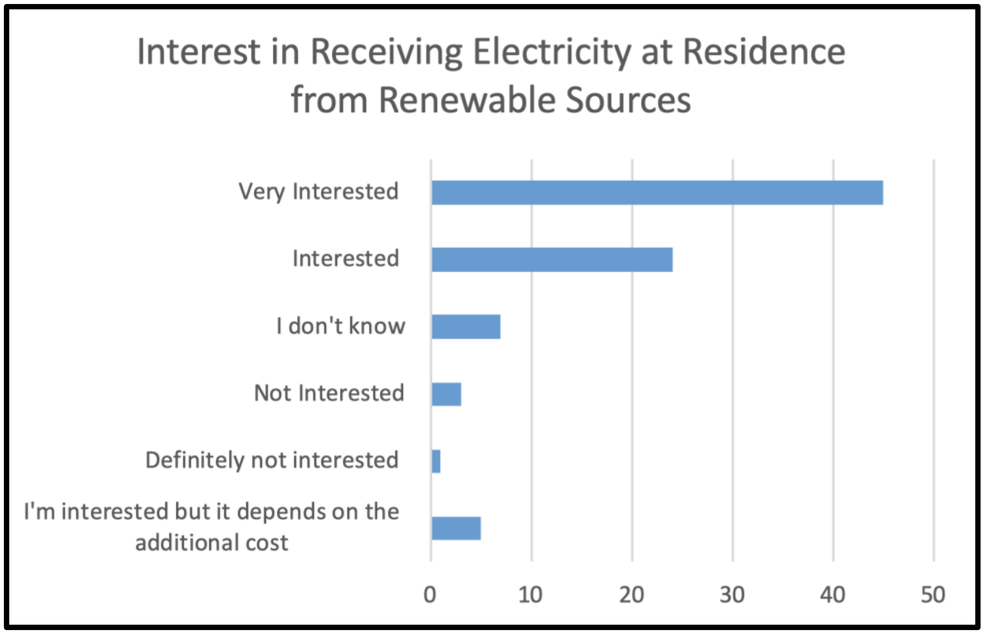

Figure 3: Amount of Saratoga County residents and their interest in renewably sourced electricity (n=83) (Opportunities for CSS, Brown & Hoffman, 2018).

The other option for accessing CSS involves Skidmore signing onto a contract with a utility-sponsored CSS project. We found this model to be very appealing because it would instantly give us a 10% reduction on our current price per kWh. In contrast to the investment option, this subscription contract would require no economic commitment or investment on behalf of Skidmore because the site has already been invested in and constructed. The site we have chosen as the most feasible for our purposes is the Dynamic Energy Altamont Community Solar Garden, shown in Figure 4.

Figure 4: Dynamic Energy Altamont Community Solar Garden.

In our conversations with Dynamic Energy, they told us that this site is relatively new, and that there is currently enough available energy to fully cover the 550,000 kWh utilized by Skidmore's auxiliary meters annually. Furthermore, this would immediately reduce what Skidmore pays for electricity on these meters by 10% (Starr, 2019). This would lower the price we pay for electricity at these meters from 14.3¢/kWh to 12.6¢/kWh. While this would still be a higher rate than the 7.6¢/kW we pay on our main meter, it is still projected to save Skidmore $9,350 annually, or almost $47,000 over five years. The breakup of these savings can be seen in Table 4 below.

Year	Annual Electricity Demand (kWh)	Electricity Rate ($/kWh)	Annual Electricity Cost ($)	Annual Savings with CSS ($)	Total Compounded Savings with CSS ($)
Current	550,000	.143	78,650	-	-
1	550,000	.126	69,300	9,350	9,350
2	550,000	.126	69,300	9,350	18,700
3	550,000	.126	69,300	9,350	28,050
4	550,000	.126	69,300	9,350	37,400
5	550,000	.126	69,300	9,350	46,750
… 20					187,000

Table 4: Potential savings from CSS contract option.

This option produced significantly less potential savings than the investment option. The $9,350/year savings we would be able to get with this option would buy only 416 RECs, which would offset 416 MWh of our electricity usage. This would give Skidmore a 2% increase in its share of electricity from renewable sources, and a reduction of only 1% of our overall GHG emissions. While this might seem like an insignificant amount, it is actually far from it. Our feasibility analysis of these two options considered several important factors including how far a project would advance Skidmore's Campus Sustainability Goals, and equally the feasibility of implementing said project.

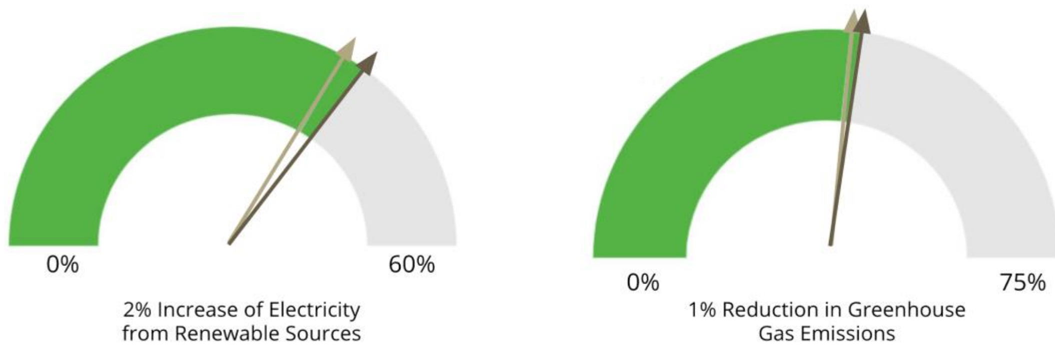

Figure 5: Dials with needles that show potential progress towards Skidmore's energy goals, accounting for progress from the CSS contract option.

Alternative Student Housing

The alternative student housing project we are proposing will take the form of tiny homes retrofitted with solar power and sustainably sourced materials. In the past 50 years the average size of the American home has nearly tripled (Adler, 2006), we consume nearly twice as much (Leonard, 2002), and it is estimated that people from the U.S. spend a total of $1.2 trillion on non-essential goods (Whitehouse, 2011). The tiny home movement is, in part, a reaction to increasing consumerism and the overarching issue of global climate change.

The carbon footprint of tiny homes is fourteen times less than the average American household; the average American household produces 28,000 pounds of carbon, whereas the average tiny home only produce 2,000 pounds of carbon (Stanford, 2015). Tiny homes are also considerably less expensive. The average American home costs $272,000, while the average tiny home costs $46,300. Roughly 68% of tiny home owners do not have a mortgage, compared to 29.3% of traditional homeowners (Huffpost, 2013).

Although acceptance of tiny homes is growing, it is often still difficult to "legally" live in tem. By and large, building codes and regulations require a minimum square footage for new-construction homes and tiny homes typically do not meet that minimum. However, many grassroots organizations are pushing legislatures to include tiny homes in their building codes and it is working (Nonko, 2013). In Saratoga Springs, tiny homes are beginning to be included in building codes and individuals looking to build or purchase a tiny home can apply for permits. They will be classified as an R-2 Occupancy and would need to be designed by an architect or engineer in conformance with all requirements of R-2 Occupancy. Saratoga Springs building codes are expected to include provisions for tiny homes by the end of 2019 or beginning of 2020 (Cogan, 2019). The incorporation of tiny homes in Saratoga Springs indicates they are not a passing fad and are viable even in the cold winter months.

The tiny home movement is also popping up on campuses all over the world. Westminster College has enacted a course in which students learned how to build and design tiny homes, and then partner with community members, faculty, staff, and alumni to build the homes. Although this course counts as an environmental science credit, students from any major are able to enroll and participate. Through this course at Westminster College, sustainable living and engagement becomes a cornerstone of their identity. (Westminster College, 2019). In Sweden, Lund University has implemented a series of "micro-dorms" that offer a sustainable alternative to typical student housing that challenges the ideals of American up-sizing (Mutter, 2013). The university has identified the positive effects of tiny homes and uses them to make a difference on not only their students, but also the environment.

We have identified two main options for implementing tiny homes on Skidmore's campus. The first option would be to purchase a prefabricated home from a trusted company that specializes in tiny home construction. The other option would to be create a year-long course where students will learn design and construction skills and work together to build their very own tiny homes, which would then be installed on campus. We have identified two locations within the Northwoods Apartment Complex that have access to water and sanitation lines (Lundberg, 2019). These locations, shown in Figure 6, are flat and have been previously cleared of trees.

Figure 6: Map of Skidmore's Northwoods Apartments, with proposed locations for tiny homes circled in red.

While there are a number of reputable tiny home construction companies such as Tumbleweed Tiny Houses, or Tiny Green Cabins, the company we decided that Modern Tiny Living is the most suitable for Skidmore. The model that we believe would be a good candidate is called “The Nugget.” These tiny homes have the ability to be off trailer, retrofitted with solar, and insulated to be winter proof. The base model for the Nugget costs $39,000, but a number of other installations would be necessary in order to make it off the grid and be considered a sustainable building. As shown in Table 4 We estimate that the total cost for “The Nugget” would be $54,500. In order to remain consistent with lower costs of tiny homes, and to incentivize students to live in them, we propose the cost of living be equivalent to the cost for a residence hall single occupancy ($9,168), which would result in a payback period of six years.

Nugget Tiny Home	**Cost ($)**
Pre-Built House	39,000
Solar Panels	3,000
Tankless Water Heater	1,400
Upgraded Floor and Water Heater	5,000
Water and Sanitation	8,500
No Steel Frame	-1,000 (savings)
Total	54,500
Cost of Residency	9,168
Payback Period	5.9 Years

Table 5: Breakdown of costs associated with prefabricated tiny home option.

The second proposal is the student built-option. With this option, we suggest the creation of a new year-long course in which students would learn about and design tiny homes in the Fall semester, and build their designs in the Spring semester. This year long course would be unique to the Environmental Studies and Sciences major, but could be offered to students across all departments. The class could enroll upwards of twenty students, and in it they will learn how to use power tools and other construction materials in the first half of the first semester, and design a home in the second half of the first semester. The second semester would consist of students building one or two homes (depending on enrollment numbers). Ideally, these students would be sophomores or juniors when they take the course so that they could potentially live in the homes the following year. Additionally, Skidmore may need to hire a visiting professor/instructor who has designed and built tiny homes before and has significant experience in construction, unless there exists a professor at Skidmore who meets this criteria.

This course would increase engagement because students and community members would be integral to the proliferation of tiny homes. The rough estimate costs of a student-built tiny house are outlined in Table 6. We estimate that a student-built tiny home would cost $30,200. Charging the same as a single occupancy residence hall, the payback period would be 3.3 years.

Student Built Tiny Homes	**Cost ($)**
Structural Costs	11,800
Solar Panels	3,000
Tankless Water Heater	1,400
Upgraded Floor and Water Heater	5,000
Water and Sanitation	8,500
Plumbing and Electrical	2,200
Total	30,200
Cost of Residency	9,168
Payback Period	3.3 Years

Table 6: Breakdown of costs associated with student-built tiny home option.

Skidmore's Campus Sustainability Plan identifies engagement as a main goal, and this alternative student housing project is intended to help Skidmore directly address it. With the tiny homes, we envision bi-monthly tours for community members interested in sustainable living. If Skidmore could provide a setting in which the ins and outs of tiny homes could be explored and experimented with, knowledge of tiny homes and what inhibits their proliferation could increase.

Having sustainable tiny homes on campus would act as an engagement opportunity not only for students and tour groups, but also for the surrounding community through community education and outreach. With a payback period of a little over three years, there is room for future students to continue to build tiny homes and encourage more students to practice daily sustainable living while quickly turning a profit.

If Skidmore were to bring to fruition solar on campus, community shared solar, and tiny homes with solar, solar power would become a pillar of Skidmore's sustainability identity, in the same way that geothermal heating and cooling has become.

Future Hydropower

To keep the energy goal needles moving in the future, we think Skidmore should look to hydropower. Through our research, we identified hydropower as a prime candidate for helping Skidmore reach its energy goals. The feasibility analysis for the hydropower project was less comprehensive than analyses for our other projects due to a lack of available data. Even so, we believe that hydropower represents a solid option for Skidmore moving forward. In working with contacts from New England Hydropower—a Massachusetts-based hydropower company that specializes in restoring old sites with small-scale Archimedes Screw technology—a potential site situated on an old canal system has been identified within Upstate New York. Archimedes screw technology, shown in Figure 7, extracts potential energy generated by water moving slowly down a set of helix-shaped blades. While the future of the project is still far from certain, it has been estimated that the nameplate capacity of the project would be 200 kW, and that it would produce 1.6 million kWh/year. Unfortunately, most other aspects of the project, including the cost of building the project and the potential price of electricity it would produce, are still indeterminable. This site does, however, represent a profile of an existing site not ready for development. With that in mind, we believe that this kind of project, if not this specific project, would represent a great addition to Skidmore's renewable energy portfolio going forward, and would help Skidmore meet its energy goals.

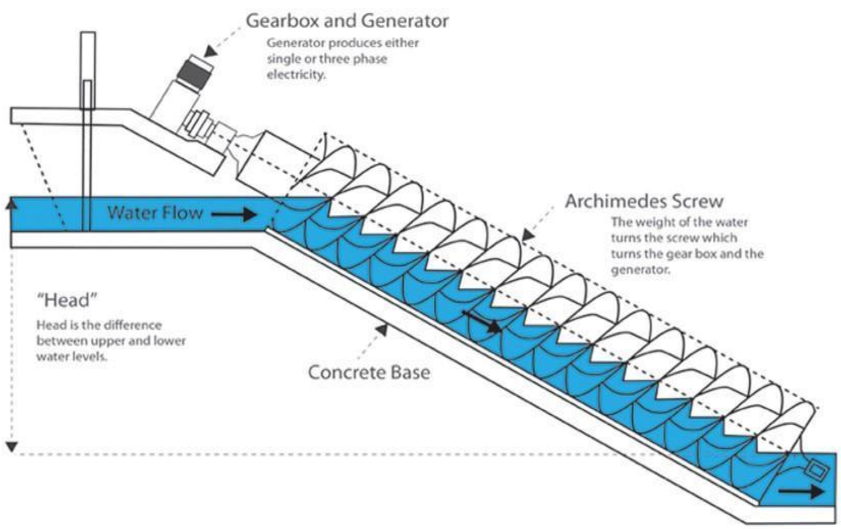

Figure 7: Diagram of Archimedes Screw construction and operation.

Conclusions

Moving forward with Solar on Campus, we recommend that Skidmore opt for the lease agreement because the projected revenue would be guaranteed, regardless of the solar panels' production. Between the lease and the PPA, the lease represents the more conservative option because the lease agreement has little to no risk involved, while the PPA-style agreement would have some risk in the form of uncertainty regarding exact quantities of energy produced.

Because of the high risk and uncertainty in the investment option for CSS, we recommend the subscription option. The investment option could be extremely lucrative for Skidmore, with the potential to cut the price we pay per kWh at these auxiliary meters nearly in half. However, the inherent uncertainty involved in an investment like this makes it too risky for

Skidmore to undertake feasibly. The subscription model has almost no uncertainty associated with it; we know where it is, we know that we could potentially sign up tomorrow if we wanted to, and we know that we would start saving 10% instantly. Therefore we recommend that Skidmore subscribe to an existing CSS project as soon as possible in order to continue contributing to our Campus Sustainability Goals.

Between the prefabricated or student built tiny homes, we recommend that Skidmore choose the student built option. The payback period for the student build option would be nearly half that of the prefabricated option. The student built option would also directly address the College's engagement goal through extensive student involvement with the creation of the tiny homes and tours for visiting students and the greater Saratoga Springs area.

Together, the proposed Solar on Campus and CSS projects would give Skidmore an 11.2% increase in its energy consumed from renewable sources, and a 4.2% reduction in GHG emissions. This progress would move Skidmore to 51.2% of electricity from renewable sources, and to an overall 45.2% reduction in GHG emissions. Figure 8 illustrates this potential progress.

While what we propose in this feasibility study would constitute significant progress towards Skidmore's energy goals, we recognize that the goals still wouldn't be quite met. Future hydropower represents one way Skidmore could continue pursuing their goals, but we also recommend that Skidmore continue to consider additional innovative solutions.

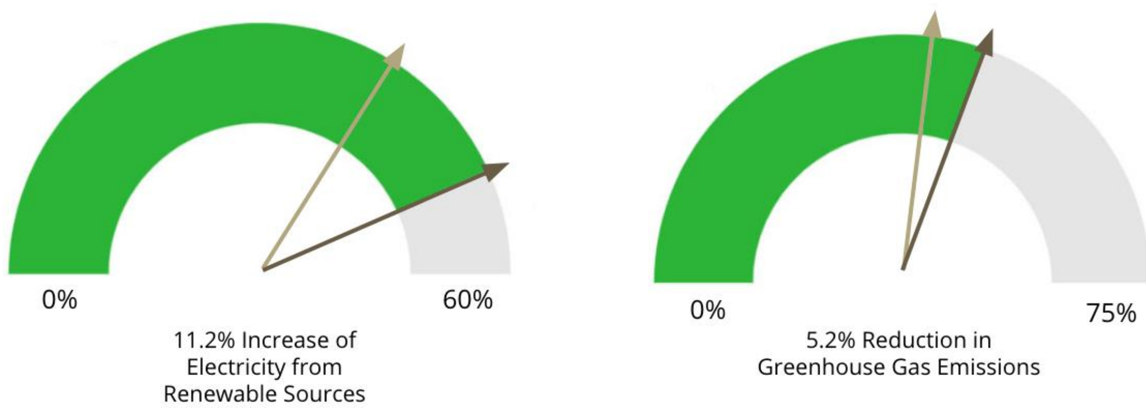

Figure 8: Dials with needles that show potential progress towards Skidmore's energy goals, accounting for progress from Solar on Campus and the CSS contract option.

Appendix: Contacts

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Other

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- Paul Lundberg, Assistant Director Construction Services: plundber@skidmore.edu
- Todd Fabozzi, Urban Planning, Visiting Professor, Chair Member of Saratoga Springs Planning Board: todd.fabozzi@skidmore.edu

References

Adler, Margot. (2006, July 4). *Behind the Ever Expanding American Dream House.* National Public Radio. Retrieved from: https://www.npr.org/templates/story/story.php?storyId=5525283?storyId=5525283

America's Pledge on Climate. (2018). *About America's Pledge.* Retrieved from: https://www.americaspledgeonclimate.com/

American University. (2018). *Carbon Neutrality is Now Reality at American University.* Retrieved from: https://www.american.edu/media/news/20180425-Carbon-Neutrality.cfm

American Wind Energy Association (2019). *Basics of Wind Energy.* Retrieved October 30, 2018 from: https://www.awea.org/wind-101/basics-of-wind-energy

Brown & Hoffman. (2018). *Opportunities for Community Shared Solar in Saratoga County: Policy, Economics & Interest.* Retrieved from https://www.skidmore.edu/wri/documents/9-CoreyHenry.pdf

Chasek, P. S., Downie, D. L., & Brown, J. (2017). Global environmental politics. Westview Press. (7th ed).

Confino, J. (2014) Best Practices in Sustainability, *The Guardian*. Retrieved from: https://www.theguardian.com/sustainable-business/blog/best-practices-sustainability-us-corporations-ceres

Cogan, P. (2019). In Martell-Crawford P. (Ed). *Email about Saratoga building codes.*

Curry, J. (2019). In Martell-Crawford P., Flanagan G. and Sachs B. (Ed). *Phone conversation about investing in Community Shared Solar.*

David Beavers, James McGuckin, and Erin Sweet. (2017). *Community Shared Solar: Review and Recommendations for Massachusetts Models*. Retrieved from: https://www.mass.gov/files/documents/2016/08/nv/community-shared-solar-model-frameworks-032813.pdf

Dynamic Energy, (2019). *Dynamic Energy New York State Community Solar Project Now Live.* Retrieved from: https://dynamicenergy.com/dynamic-energy-new-york-state-community-solar-project-now-live/

Fossil Free: Divestment. (2019). *What is Fossil Fuel Divestment?* Retrieved from: https://gofossilfree.org/divestment/commitments/

Gorey, J. (2019, April 30). *Half of Americans Would at Least Consider a Tiny House, New Study Reports.* Retrieved from: https://www.apartmenttherapy.com/tiny-house-survey-americans-consider-small-2018-257371

Huffpost. (September 4, 2013). *Shows 68 Percent Of Small-Space Dwellers Don't Have A Mortgage.* Retrieved from https://www.huffpost.com/entry/tiny-home-infographic-mortage_n_3867269

Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014 Synthesis Report.* Retrieved from: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf

International Energy Agency, *World Energy Outlook* (2017). Retrieved from: https://www.iea.org/weo2017/

Interstate Renewable Energy Council. (2012). *Community-Shared Solar: Diverse Approaches for a Common Goal.* Retrieved from: https://irecusa.org/publications/community-shared-solar-diverse-approaches-for-a-common-goal/

Interstate Renewable Energy Council. (2013). *Model Rules For Shared Renewable Energy Programs*. Retrieved from: http://www.irecusa.org/wp-content/uploads/2013/06/IREC-Model-Rules-for-Shared-Renewable-Energy-Programs-2013.pdf

Jennifer Phelps. (2015). *Community Shared Solar Program: Final Initiative-Level Logic Model Report.* Retrieved from The New York State Energy Research and Development Authority Website: community solar ny program - NYSERDA - NY.gov

Leonard, Annie. (2002). *Story of Stuff, Referenced and Annotated Script.* Retrieved from: http://storyofstuff.org/wp-content/uploads/movies/scripts/Story%20of%20Stuff.pdf

Lundberg, P. (2019). In Martell-Crawford P., Flanagan G. and Sachs B. (Eds). *Conversation at Skidmore Facilities Services.*

Mutter, A. (2013). *Growing Tiny Houses Motivations and Opportunities for Expansion Through Niche Markets.* Lund University. Retrieved from: http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=4196241&fileOId=4196242

Nonko, Emily. (2016, September 22). *Tiny house zoning regulations: What you need to know.* Curbed. Retrieved from: https://www.curbed.com/2016/9/22/13002832/tiny-house-zoning-laws-regulations

NYSERDA. (2019). *Community Distributed Generation: Overview for Project Developers.* NY-SUN.ny.gov. Retrieved from: https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun

NYSERDA. (2019). 2019 Compliance Year. Retrieved from: https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard/REC-and-

ZEC-Purchasers/2019-Compliance-Year

The Princeton Review. (2018, October 16). *Guide to 399 Green Colleges: 2018 Edition Press Release.* Retrieved from: https://www.princetonreview.com/press/green-guide/press-release

The Princeton Review. (2019). *Top 50 Green Colleges*. Retrieved from: https://www.princetonreview.com/college-rankings?rankings=top-50-green-colleges&page=2

Skidmore's solar array completed, generating power. (2014, October 7). Retrieved October 30, 2018, from: https://www.skidmore.edu/news/2014/1007-skidmore-celebrates-solar-array.php

Skidmore College. (2007). *Campus Plan*. Retrieved from: https://www.skidmore.edu/planning/2007/documents/FullPlan2007.pdf

Skidmore College. (2015). *Campus Sustainability Plan*. Retrieved from: https://www.skidmore.edu/sustainability/documents/2015CampusSustainabilityPlan.pdf

Skidmore College. (2018) *Skidmore College 2017-2018 Annual Sustainability Report* https://www.skidmore.edu/sustainability/2017-18AnnualReport.Compressed.FINAL.pdf

Solar Energy Industries Association. (2019). *Solar Industry Research Data.* Retrieved from: https://www.seia.org/solar-industry-research-data

Stanford, D. (2015, December 14). *Tiny Houses Have Even Tinier Carbon Footprints.* Retrieved from: https://www.renewableenergyworld.com/ugc/articles/2015/12/tiny-houses-have-even-tinier-carbon-footprints.html

Starr, S. (2019) In Martell-Crawford P., Flanagan G. and Sachs B. (Eds). *Conversations about Subscription Community Shared Solar.*

US Department of Energy, Sun Shot. (2012). *A Guide to Community Solar: Utility, Private, and Non-profit Project Development.* Retrieved from: https://www.nrel.gov/docs/fy12osti/54570.pdf

US Energy Information Administration. (2017). *International Energy Outlook 2017*. Retrieved from: https://www.eia.gov/outlooks/archive/ieo17/pdf/0484(2017).pdf

US Energy Information Administration. (2019). *U.S. Energy Facts Explained*. Retrieved from: https://www.eia.gov/energyexplained/?page=us_energy_home

United Nations. (2017). *Sustainable Development Goals*. Retrieved from: https://www.un.org/sustainabledevelopment/energy/

Westminster College. *Environmental Science: Tiny House Project.* Retrieved from: https://www.westminster.edu/academics/majors-programs/environmental-science/tiny-house-project.cfm

Whitehouse, Mark. (2011, April 23). *Number of the Week: Americans Buy More Stuff They Don't Need.* Retrieved from: https://blogs.wsj.com/economics/2011/04/23/number-of-the-week-americans-buy-more-stuff-they-dont-need/