Financial Analysis of University Investments in Solar Photovoltaics

William Arnett
Purdue University, United States of America, arnettw@purdue.edu

Praneet Arshi
Purdue University, United States of America, parshi@purdue.edu

William Hurtzel
Purdue University, United States of America, hurtzelw@purdue.edu

Brittany Newell
Purdue University, United States of America, bnewell1@purdue.edu

John Piller
Purdue University, United States of America, jpiller@purdue.edu

Financial Analysis of University Investments in Solar Photovoltaics

William Arnett[1]*, Praneet Arshi[2], William Hutzel[3]*, Brittany Newell[4], John Piller[5]

School of Engineering Technology, Purdue University
West Lafayette, IN, United States of America

[1]arnettw@purdue.edu
[2]parshi@purdue.edu
[3]hutzelw@purdue.edu
[4]bnewell1@purdue.edu
[5]jpiller@purdue.edu

* Corresponding Author

ABSTRACT

The global demand for electrical energy is increasing as a result of population growth and a higher standard of living that is enjoyed by many people. However, the availability of electricity is often limited by fuel supplies and/or infrastructure for generating and distributing power. In addition, the looming threat of greenhouse gas emissions and the collateral damage to the environment has encouraged efforts to diversify methods of electricity production. These factors have led to the increased use of renewable energy, particularly solar and wind, to help meet the demand for energy. The shift towards solar energy has been accelerating due to the decreasing cost of materials and installation.

A project funded by the U.S Department of Energy's Sunshot Initiative is looking at the economics of solar energy for universities. In particular the project is looking at whether university endowments, which seek to make a long term financial return to the university, can view solar electricity as an investment opportunity. This financial incentive, along with the mission of a university to showcase new technologies, could be helpful for deploying more utility-scale solar electricity at university campuses. The university that is the case study for this research enjoys exceptionally low cost for electricity due to its on-campus combined heat power plant. This low cost of electricity generation makes it difficult to justify utility scale solar energy unless creative financing strategies are used.

1. INTRODUCTION

This research is a case study of the financing options and factors for implementing photovoltaics at a university in Indiana. This university offers a unique set of challenges for financing due to the low rate that is paid for the electricity that is used because of the on-campus Combined Heat Power plant (CHP). To justify the cost of solar photovoltaic electricity, the cost of electricity ultimately has to be designed around the total production value, matching the timing of production with the peak rates seen in order to minimize the payback of the investment. (Energy Information Administration, 2015). In an ideal situation, the demand for electricity would peak at the same time that a solar photovoltaic array generates its peak output.

Peak electrical demand and output typically occurs in the afternoon, according to the university's Energy Office. This peak develops when the campus is active and the sun is directly overhead. Following the economic rules of supply and demand, the value of this peak electricity should be higher than electricity used during periods when less energy is being used. This research focuses on 1) understanding how electricity is used on a university campus and 2) evaluating the available financing options to determine which option is most compatible with the university's operating strategy. This research can be a template for other universities that are considering similar renewable energy installations. While each university will have varying criteria, the methodology that is presented can help others understand the financing considerations. It is expected that universities will have different priorities and thus different financing strategies will be used.

2. HISTORICAL PV COST TRENDS

Figure 1 is a graph developed by Lawrence Berkeley National Laboratory in their annual report called "Tracking the Sun" that illustrates the decreasing cost of photovoltaics (PV), while also showing the economy of scale. The independent (horizontal) axis is the year of PV installation and the dependent (vertical) axis is the project cost in $/Watt using 2014 as the base year. The graph clearly shows that as technology progresses the cost of manufacturing photovoltaic panels decreases. The installation cost of PVs has also decreased, which plays a significant role in the financial feasibility of implementing photovoltaics. This decreased cost is also complimented by the economy of scale, which makes the installation of a larger system relatively cheaper on a unit cost basis.

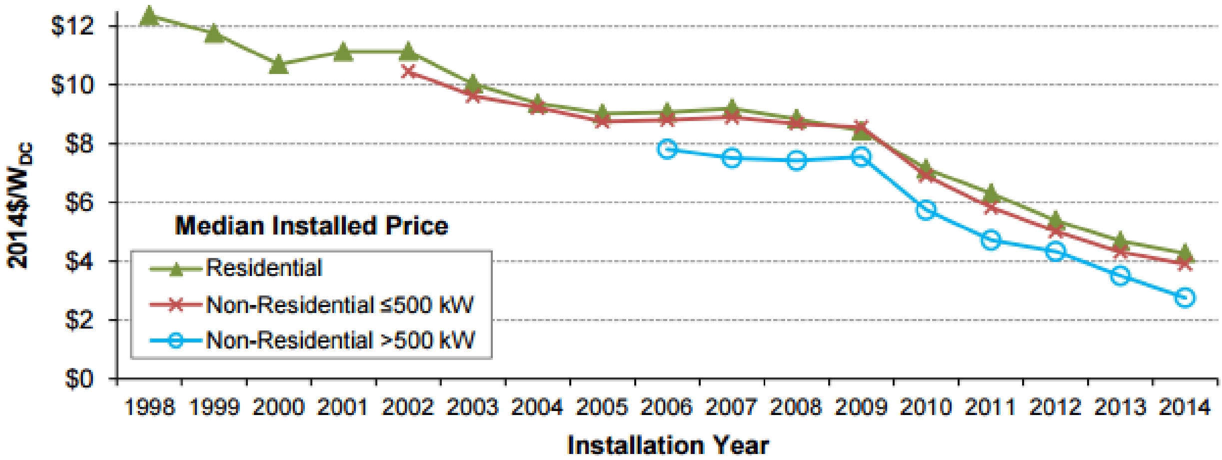

Figure 1: The installed cost of solar PV is trending downward. (Feldman *et al.*, 2014)

The two non-residential trends from Figure 1 are the key aspects to consider. A larger system size, signified by the blue line in Figure 1, costs less than a smaller system size (red line) for any given year. A larger size of installation means a larger total cost but a lower unit electricity cost, which increases the Return on Investment (ROI) for the system. Figure 1 indicates that any system greater than 500 kW is considered utility scale, but larger systems achieve greater economies of scale and thus are easier to finance.

For the case study in question, a 5 MW photovoltaic system is being considered. Local photovoltaic contractors in the state of Indiana estimate that the current installation cost of a 5 MW system would be approximately $1.60-$1.70/W. As a point of comparison, the Sunshot Initiative that is managed by the U.S. Department of Energy's National Renewable Energy Lab estimates that when solar PV achieves an installed price of $1/Watt it will have reached grid parity with other sources of electricity. If the trend of decreasing prices continues according to Figure 1, utility scale PV could be financially competitive with traditional fossil fuels in the next 5 to 10 years. Thus a solar installation that is not quite cost competitive today can still be viewed as a smart investment over its 25 year life span as a hedge against the steadily increasing cost of electricity from traditional fuel sources.

3. ELECTRIC RATES

The basic premise for net metering sets the value of electricity generated by a solar photovoltaic array equal to the retail rate provided by the local electric utility. Although this seems like an obvious assumption, recent actions by electric utilities in the U.S. have cast doubt on this approach. Legislators in Indiana recently considered a bill that would reduce the net metering rates paid for solar electricity because of its intermittent nature and because local solar installations do not contribute to the costs of operating and maintaining the distribution/transmission grid that is provided by the local electric utility.

The university in this case study owns a combined heat and power (CHP) plant, which provides approximately 1/3 of the total campus electricity annually. Due to the university owned CHP, electricity is generated and purchased at a low rate. The university also has an agreement with the local utility so that they can make flexible economic decisions on when to increase production, or purchase more energy. This drives the average price down to $0.06/kWh, which is what the university uses to determine the payback of energy conservation and improvement measures (Hutzel *et al.*, 2015).

Figure 2 compares the national and state average electrical rates to the cost of electricity at the university with a CHP. The vertical axis is the cost of generation in cents per kWh. The national average (blue) is approximately 13 cents per kWh. The cost of generation in Indiana (red) is about 11 cents per kWh due to an abundance of low cost coal. The university's electrical average cost of generation (green) is less than half of the national average. This low rate, approximately 6 cents per kWh, does not imply that a solar project cannot be justified financially. The low value only implies that the return on investment and payback period will take longer and emphasizes the need for innovative financing to make the project profitable.

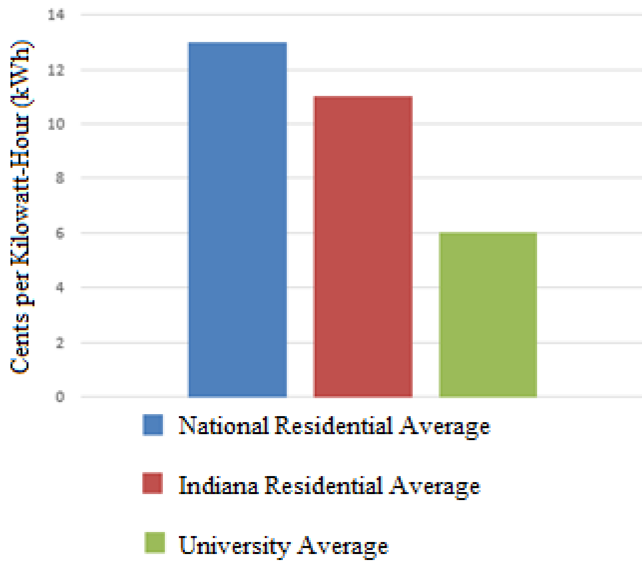

Figure 2: Comparing U.S. electric rates (Landry, 2015)

4. ELECTRICITY CONSUMPTION ANALYSIS

Understanding how photovoltaics integrates in the university's electric consumption is crucial to quantifying the financial impact. This case study assumes that the utility-scale solar energy system is located on or near the campus so that all of the energy is consumed locally by the university. This "inside the fence" option is easier to implement because it does not require the negotiation of a power purchase agreement with the local electric utility. It has the additional advantage of providing a direct hedge against future cost increases for energy. The operators of the power plant also like the "inside the fence" option because two local sources of electricity (CHP and solar) potentially offers more flexibility in terms of scheduling down time for maintenance at the power plant.

This case study considered a 5 MW solar energy system, which would provide up to 3% of the university's annual consumption in 2014. Part of this selection was based on the physical size of the solar installation. 1 MW of solar electricity requires approximately 6 acres of land in the Midwest (Ong *et al., 2013*). Scaling up this size shows that 5 MW of solar would take approximately 30 acres of land. Finding the physical space for anything larger than 30 acres close to the university campus would be difficult if not impossible. The ideal location is one that is close to an existing electric distribution network for easy grid connectivity and also on land that cannot be developed for other purposes, such as the restricted space surrounding the runway of an airport.

The university in this case study acquires electricity in three ways. One method is purchasing electricity at a “base” rate. A base value is a set amount of electricity purchased a year in advance by the university from the local utility company. This value is negotiated between the university’s energy office and the local utility. The fact that the university has the ability to generate its own electricity enhances its ability to negotiate low costs with the utility.

Another way of getting electricity is purchasing it at a Real Time Pricing (RTP) rate. RTP is a rate that changes every hour and the price is determined a day in advance. The rate varies over the course of a day and also varies due to weather. The RTP price is generally higher during times of peak demand, like during hot weather. The RTP values are provided to the university power plant operators, who then make the decision to generate or purchase electricity based on whatever option is the cheapest.

Generating electricity through the university’s CHP is the third method for meeting campus electricity demands. The university’s power plant produces not only electricity, but is also the main supply of heating and cooling for the campus. Some amount of electricity is always being generated as a by-product of producing heating or cooling. Any additional electricity generation is based off of the RTP prices from the electric utility. Each day when the RTP prices are provided, the university energy office determines if it’s cheaper to purchase or generate electricity for each hour of the next day.

Figure 3 shows the interplay of the three main electrical sources for 2014, with a solar component added. The horizontal axis represents each day of the 365 day calendar year. The vertical axis shows the sources of electricity for each day expressed as a percentage. Each day of electricity consumption is represented as a combination of base, RTP, or CHP. Solar energy (yellow) for a 5 MW system is added into the graph to show its potential contribution. On any given day, the contribution of RTP, CHP, Base, and Solar adds to 100%.

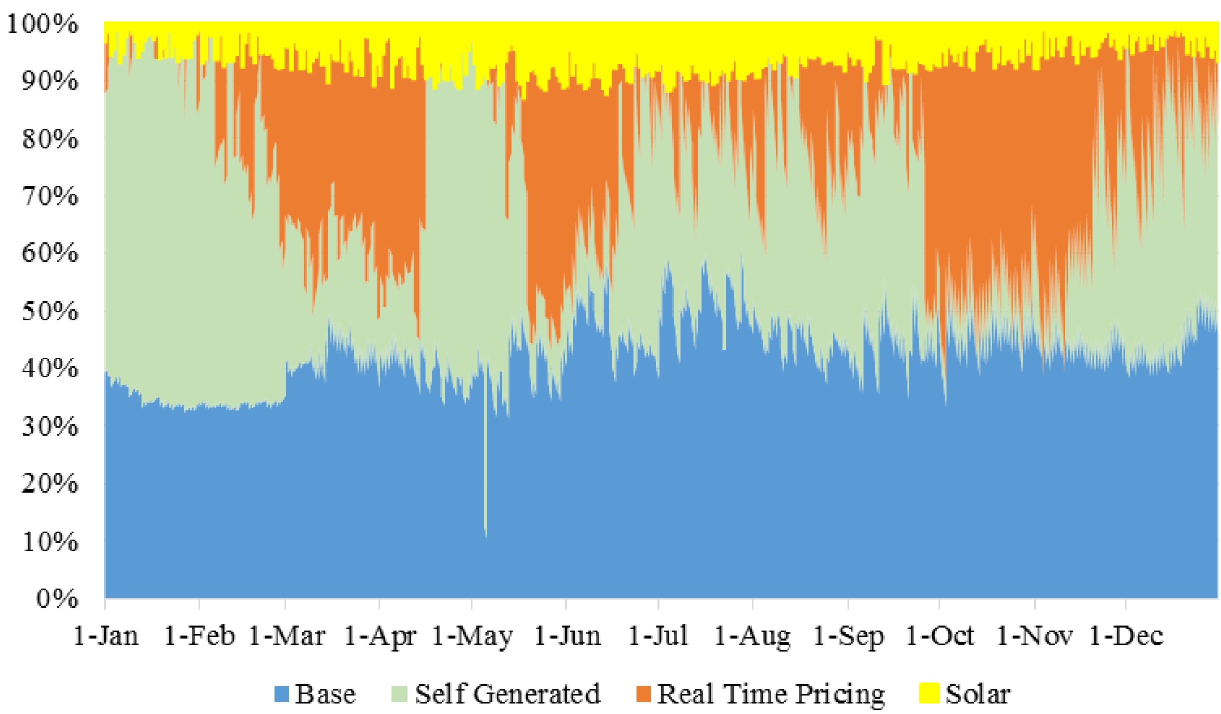

Figure 3: 2014 University’s annual electric consumption with solar (Landry, 2015)

Figure 3 illustrates how the university makes decisions about energy generation. The impact of the very cold weather associated with the polar vortex that occurred in January of 2014 can be easily seen. During this time period the RTP price for electricity was quite high. As a result the university opted to self-generate, which is shown by the large amount of CHP (green) power in early January. The weather had moderated by March, so the price signal for RTP dropped by a corresponding amount. As a result the university purchased more power, which is shown by the large amount of RTP (orange) energy in April and May.

Figure 3 also shows the impact of a 5 MW array in the context of the university's energy consumption. This is illustrated by the yellow band at the top of the figure. The band of solar is wider in the summer, because the long summer days allow for the solar array to supply a greater percentage of the electricity consumed. The yellow band is narrower from November through February because of the relatively short days and lack of sunshine.

Figure 3 also clearly shows the intermittent nature of solar energy because the yellow band in not smooth, but instead has peaks and valleys due to daily weather related anomalies. This simulated 5 MW solar array would provide roughly 3% of the university's total electricity requirements. The solar energy predicted is based off scaling a small PV array located on a university building. Energy production values were collected for a year, and then scaled to a 5 MW system size. Degradation was accounted during these calculations to normalize the values (Landry, 2015).

5. FINANCING OPTIONS AND MECHANICS

One of the major criteria in evaluating photovoltaic implementation is project financing. There are three potential methods for the university to invest in a PV system, and four decision factors that accompany each method. Each method provides a unique set of benefits and concerns, which can be weighted differently based on the priorities of the university. The following narrative explains each option in greater detail.

University owned is one of the most basic financing options. Under this scenario, the university would directly purchase the solar array using the investment capital in its endowment. This approach has the advantage of putting the university in full control of the operation of the array, including ownership of the Renewable Energy Credits (RECs) that accumulate to any green source of electricity. All energy produced by the system would be used by the university to reduce electric purchases from the local utility, or be sold to the local utility through a negotiated power purchasing agreement (PPA) depending on grid interconnect location. The main drawback to this approach is the perceived risk of the investment in terms of whether the solar array would live up to its performance expectations over its 25 year life span. There is additional uncertainty as to whether this type of investment could live up to the ROI expectations from the university's investment office, particularly since the installation may not automatically qualify for the 30% solar tax credit that is available to entities with a tax appetite.

Third party owned is another financing option where the solar array is funded by a university alumni or other generous benefactor. The university provides land near a utility interconnect to the third party, with the value of the land being calculated into the power purchasing agreement. Here the third party could take advantage of the federal tax incentives and rapid depreciation for solar projects, but still sell the electricity back to the university at a low rate. By largely eliminating the upfront cost to the university, the third party PPA could be set to a lower value while still maintaining a positive net present value (NPV) that benefits both groups. This opportunity offers a unique appeal since a generous alumni would be less motivated by profit, and more by promoting renewable energies and the image of the university. All things being equal, this option would likely deliver the greatest financial benefit to the university.

Land lease is a financing option where the university leases land to the local utility and then the utility constructs the PV system. This method is attractive because it has minimal risk to the university. The utility is responsible for all expenses and costs due to equipment malfunctions. With this structure the utility would own the system, making them accountable for all operation and maintenance costs. These expenses would be calculated into the land lease arrangement. One negative side effect is that the utility would also own the RECs generated by the solar array, limiting the university's ability to claim responsibility for reducing greenhouse gas emissions. While this financing option offers the lowest financial returns, the revenue generated can be used wisely. Some potential uses for the land leasing revenue include using the funds to establish additional renewable energy systems, purchase other low cost RECs to benefit sustainably and to help keep tuition costs from increasing.

Once the preferred financing options were identified each one was valued based on the operating priorities of the university. Four types of decision factors were presented; financial, risk mitigation, energy security, and sustainability. Table 1 provides a list of each decision factor and values them according to "high", "medium", or "low" values. A "high" value means that the decision factor embodies that attribute to a high degree. For example, a "high" value for financing means that strategy would likely have a high return on investment. On the other hand, "high" risk mitigation means that option carries investing with little or no risk. This type of ranking system helps identify financing options that align closely with the operational goals for the university.

Table 1: Financing options and decision factors

Decision Factors	University Owned	3rd Party (Donor) Owned	Land Leasing – Local Utility
Financial (Payback/ROI)	M	H	L
Risk Mitigation	L	M	H
Energy Security	H	H	L
Sustainability	H	H	M

H=High, M=Medium, L=Low (Levels)

Table 1 demonstrates the rankings for each financing method. With all things weighted equally, the 3rd party option has the best overall ranking because it has three "high" rankings and one "medium" ranking. The findings are not quite that simple, because the decision factors may not be weighted equally. The university considering these methods seems more interested in risk mitigation than financial payback. With this additional consideration, the land leasing option is the most beneficial, 3rd party owned is second, and university owned is last. A detailed list of the decision factors is listed below to better define each term.

5.1 Financial (Payback, ROI)

This decision factor is purely based on financial value generated by the system. The total revenue generated from the system, such as net present value or annual annuity, is what defines this factor.

A land leasing agreement would allow for positive cash flow from year 1, but the lease value will generally have a lower NPV and ROI than the other two options. The donor option would likely have the highest return to the university since financing is actually a form of gift to the university.

5.2 Risk Mitigation

Risk mitigation is a decision factor based off how risky the investment is to the university. This includes which party makes the initial investment and pays all Operations and Maintenance expenses. The ideal, or high value, for this factor would consist of another party, other than the university, being liable for these costs.

For land leasing, the system is owned by the local utility, so the university is not responsible for upfront or maintenance costs. A third party owner, potentially a university alumni, takes on all responsibilities of the system. While this still doesn't affect the university directly, the funding from the donor could potentially be invested in another area, creating a "medium" risk avoidance scenario. The university owned array scenario has the lowest rating since the university would be responsible for any damages and so forth.

5.3 Energy Security

Energy security is defined by the PV system's grid connection. A desired interconnect would be on the university grid, with unrestricted access to the power in times of need.

Depending on the financing method the system could also be tied into the local utility grid. By tying into the university grid, the system would provide a consistent electrical source for the campus, which would create a high energy security value. Any additional electricity not consumed by the university could be sold back to the local utility, through net metering or a PPA.

Both university and 3rd party owned options could potentially be tied into the university's electrical grid, which would offset any RTP or CHP power consumption. These options also have the potential to be tied into the local utility, depending on negotiations and university preference. On the other hand, the land leasing option would be located in the local utilities grid. In addition, the local utility would treat the system as a power generating piece of equipment, and have no PPA with the university.

5.4 Sustainability

The sustainability decision factor relates to the environmental benefits the university could indulge in by owning the Renewable Energy Certificates. For the case study, Renewable Energy Certificates can be beneficial. If the university can own or generate the RECs it will be valued as "high". Since the university owns a combined heat and power plant, there is a basic need/desire for reducing carbon emissions. A REC is proof that an institute is purchasing green energy, since 1 REC = 1 MWh of "green" energy.

As seen in Table 1, both university owned and 3rd party owned financing options have a high sustainability rating. This is because the university would have, at least the option to purchase or generate the RECs and benefit from them. The land leasing option is ranked at a medium value, since the local utility will keep the RECs, but the generated revenue could purchase RECs from another renewable source. The potential RECs for purchase depend on the negotiated land leasing rate, and where the RECs would be purchased.

6. CONCLUSIONS

The results of an analysis of energy consumption patterns and financing options suggest that a 3rd party donor would be the most financially beneficial option. That being said the weight values of each section, such as risk mitigation, is subject to change according to the university's operational priorities. Since the university has not invested in renewable energies of this magnitude, they may value the risk avoidance overall. With that in mind, the land leasing option appears to have the highest probability of implementation.

Future steps for this research include doing an economic analysis on the various financing methods. This will require direct interaction and cooperation from the university's physical facilities, along with external sources such as the local utility and PV contractors. Each method will be reviewed for payback time frame, return on investment, and the net present value.

REFERENCES

Energy Information Administration, "Electric Power Monthly", with Data for April 2015, June 2015, http://www.eia.gov/electricity/monthly/pdf/epm.pdf

Feldman D., G. Barbose, R. Margolis, T. James, S. Weaver, N. Darghouth, R. Fu, C. Davidson, & R. Wiser. (2014). *Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections*. 2014 Edition. Golden, CO: National Renewable Energy Laboratory.

Hutzel, William, Landry, Samuel, Schuster, Daniel, and Lynall, Matthew, (2016), *University investments in solar photovoltaics – the solar endowment*, Proceedings of the 2016 ASHRAE Annual Meeting, Orlando, FL, 8 p.

Landry, S. J. (2015). *Process development for evaluating utility scale solar at a combined heat and power facility* (Order No. 10056389). Available from Dissertations & Theses @ CIC Institutions; ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global. (1776459167). Retrieved from http://search.proquest.com/docview/1776459167?accountid=13360

Ong S., Campbell C., Denholm P., Margolis R., & Heath G. (2013). *Land-Use Requirements for Solar Power Plants in the United States*. National Renewable Energy Laboratory.

ACKNOWLEDGEMENT

The information, data, and work presented herein was funded in part by the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, under Award Number DE-EE0006910.