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Home Energy Storage Options and Economic Values

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Abstract

This paper aims to analyze the economic benefit of installing a residential solar array in Portland, Oregon. Economic analysis is also performed for the excess energy generated which can be stored in the battery or can be sold back to the utility. On a basic level, solar panels convert the sun's rays into electricity. Three solar systems with varied sizes were evaluated to identify the system size with maximum benefit. Through the analysis, a system size of less than 5kW was found to have the maximum cost-to-benefit ratio. The benefits of installing solar panel include: federal and state tax credit, along with an incentive from Energy Trust of Oregon (ETO). Five batteries were analyzed namely Tesla, LG Chem Resu 10, RedFlow Zcell, BYD B-Box LV Residential and Sonnen.

Real customer data of an already installed solar array in Hillsboro was used for analysis. The electric bills before and after the array installation were analyzed. A 20 year cash flow was developed from the data gathered, and the internal rate of return, net present value and payback period were calculated. Then, sensitivity analysis was also performed by varying the energy consumption, size of the system, electricity rate, the forecasted increase in electricity rate over the next 20 years. We found that energy consumption did not have any impact on the internal rate of return and net present value of a system at this time. However, electricity rate increase and system size had an impact on the internal rate of return and net present value. Sensitivity analysis showed that investing in a solar system is a good economic decision, but that it would take a while to get the money back. Finally, the analysis also showed that smaller solar systems have good internal rates of return, and net present values and that there is no economic benefit in installing battery system in Oregon at this time.

Introduction

All over Oregon, more and more people are installing solar arrays on top of their roofs. While some homeowners are undoubtedly choosing to install systems with environmental concerns in mind, others might be looking for ways to lower their energy bills, and others still, might be taking the plunge with both reasons in mind. Regardless of reason, getting rooftop solar has gotten much easier in recent years. There are many established companies who manufacture and install solar panels, and provide estimates of power production, along with estimated return on investment calculations. As a group, we decided to investigate whether or not installing an array in and around Portland made for an economically sound investment, and furthermore if adding batteries, to store the energy produced from solar for later use would be worthwhile.

Taking into account a number of simple assumptions, we based our analysis on a currently installed system in the Portland metro area, historical data for the location, as well as a number of bids for proposed system sizes and decided to see if we could validate the data we found in the bids. We used the Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period calculations for a variety of system sizes. As we performed our analysis and learned more about the incentives & benefits, the process of going solar, and connecting systems to the grid we thought that our findings would be relatively straightforward, however that turned out not to be true -- our discoveries are detailed in the case study that follows.

Home Energy Generation and Storage

Home Energy Generation

In the state of Oregon, homeowners have a number of renewable power options available when it comes to power generation. From the more common, residential rooftop solar array, to the more uncommon and larger scale options like wind or hydropower [7]. Today however, the majority of home energy generation in Oregon is made up of rooftop solar - where solar panels are added to the roof of a residence, and convert the sun's rays into electricity [8].

All current solar panels are made up of arrays of solar cells, which convert the sun's rays into a flow of electrons via the photovoltaic effect [9]. These panels are then linked to one another to form a solar array, which is finally mounted on the roof of the house. Usually, the size of the roof, or the available square footage of the roof surface determines the maximum size of the array – the bigger the roof, the bigger the array and the more power it is able to generate. From the array, power is sent to an inverter and then either consumed, stored for later use, or distributed out to the grid. The solar array, coupled with the inverter, and optional battery makes up a solar system.

The first silicon solar cell introduced by Bell Labs in 1954, was only 6% efficient in converting the sun's rays into electricity. Today, commercially available panels range from as low as 18% to as high as 24.1% efficiency [10]. Along with increased efficiency, panels have seen a steady drop in installation costs, and as of Q3 2016, were as low as $2/W, making home solar an increasingly viable solution for home generation [11].

It should not come as a surprise that over 10,000 homes have installed rooftop solar, as photovoltaic (PV) installation have been gaining significant ground in recent times. Through Q1, Q2 & Q3 of 2016 PV accounted for nearly 34% of new US electricity generation. when we consider that in the United States, 8 Gigawatts (GW) of solar power generation were installed in the first 9 months of 2016, bringing the cumulative installed capacity for solar power to 34GW [11].

Home Energy Storage

Energy storage has not changed much as far as consumers are concerned in the last 50 years. In that time the Duracell brand was introduced and the first battery was used on the moon in the 1960s [15]. Fifty years later, consumers can still purchase Duracell batteries in most stores, and in some cases the basic chemical composition is the same as they were in the 60s. While initial consumer drive for battery production was due to flash cameras, today virtually all devices in modern life rely on power in a hyper-connected world. Battery life is typically a key value driver when people are shopping for new laptops or cellphones, and today even an average person can walk into a car dealership and purchase a vehicle with batteries where a gas tank typically would be.

Energy storage technology in general is more inventive and dynamic than average consumers are exposed to. At the grid level, adjusting power generation to match draw is complex and costly process. Hydroelectric dams use a method to capture lags in power draw by using the excess energy to pump water to higher elevation storage locations, which allows them the ability to release the stored water back through the dam to generate power. While this may sound like an outlier, this pumped-water method accounts for 2% of the United States electrical generation capacity [19]. Other storage techniques include compressing air for later release, using rail cars and electric motors, and flywheels (like those found in cars) [16].

While industrial applications are able to take advantage of non-conventional storage, residential use is still limited to battery systems. There are no shortage of manufacturers selling battery units designed for home solar (and in some cases non-solar capable) systems [20]. Consumers have different desires when considering home battery systems that can range from going off the grid, to mitigating against peak usage charges, to protecting themselves from brown/blackouts [21]. These usages can vary by region and availability of battery system types. The main technologies behind the batteries have not changed significantly in recent years, and are similar to those in today's laptops and phones. Home systems will generally use lithium-based batteries, and most commonly use lithium-ion (li-ion) or lithium-iron-phosphate (LiFePO4) [19]. The differences lie in cost, power density, operational temperature, lifetime cycles, and safety [23].

Energy storage for home users would appear to be a safe and convenient project, considering the age of the technology and the scale it is used, however there are still very real safety concerns that must be understood. In an article for Scientific American, Paul Denholm an energy analyst at the National Renewable Energy Laboratory, is quoted as saying "Clearly, storing large amounts of energy is difficult from a physics standpoint; [the energy] would rather be somewhere else" [25]. Most energy systems for home are not one large battery, but many battery cells linked together. This helps isolate failures, control heat, and allow for scalability [25]. Lithium-based batteries have been known to catch fire injuring consumers as well as behave differently when burning than other materials. Numerous device recalls such as the Samsung Note 7, and travel bans on items with lithium-ion batteries like "hoverboards" are banned from airline cargo [26].

Case Definition

To study the cost benefits of solar, we utilized data from a customer that recently installed solar on his house in Hillsboro. This customer paid outright for the solar installation, and therefore we will not evaluate the benefits of leasing against buying outright in the scope of this project. We will compare the overall consumption from each month against what is generated to determine what was saved throughout that year. We will then compare this to the costs of what the electric bill would be if solar had not been installed.

Considering this installation, the excess generation of the solar system will be broken out, in order to evaluate if it would be more cost beneficial to sell the power back to the utility, or to store it in a battery and use it for consumption at other times of the day, when the solar panels are not generating.

A summary of the system is presented in the table below.

Location	Hillsboro, OR
Size of Household	3 Bedroom
Monthly Power Bill Average	$140
Annual Power Bill	$1,677
Price of Power	11.55c/kWh [37]
Monthly Electric Usage	1,230 kWh
Annual Electric Usage	14,760 kWh
Electric Provider	PGE
Size of Solar System	5.98 kW
Lifetime of Solar System	20 years

Table I. Case Profile

Case Assumptions

Some assumptions were made for our solar system analysis and review. First, we assumed that people looking into energy generation and/or energy storage systems would be interested in their energy usage habits and that would willing to invest in technologies at a not-insignificant cost -- they would also be interested in monitoring their power usage, to perhaps become more efficient on principle; not strictly for economic reasons. There are other non-economic benefits as well, such as less reliance on government services, disaster preparedness with generation and storage (battery), and less exposure to brownouts or blackouts which can damage equipment.

We assumed that people looking into any solar or energy storage system would either already have the initial funds needed to purchase said system or they would be considering which system to invest in and thus how much money to save. Additionally, potential buyers would not be considering diesel generators (which use fuel as the energy storage) due to environmental concerns.

Since the market for energy generation and storage is changing at a rapid pace, and many new battery systems and solar systems are available each quarter, we considered only the systems proposed for our case study property. This assumption was taken so that no additional structural work or roof replacements would be needed before a system would be installed.

The property considered would be in the Portland Oregon metro area. This allowed us to take specific government incentives into consideration on the State and Local level. It's worth noting that incentives vary greatly from state to state and sometimes even county to county.

In order to evaluate the cost savings over the life of the system, we assumed that electricity would increase by 2.3% each year. This was based on predictions by the Energy Information Administration that the national average of the price of electricity would increase from 12.55 cents in 2016, to 12.85 in 2017, and to 13.15 in 2018 [30]. This is in line with inflation rates on average for the United States which can range from -1% to 3% [31].

Analysis

Existing Solar Evaluation Tools

There are a number of tools available to consumers which can help estimate the production capabilities and benefits of residential systems. Most vendors spend a large amount of effort to customize reports for locations that are considering solar (as each installation can vary), and provide production estimates along with quotes. One such tool is Google's "Project Sunroof" [32] which will give quick estimates while just requiring minimal information such as address and average monthly power bills. The National Renewable Energy Laboratory (NREL) provides an in depth tool to estimate hour-by-hour output of a system called the "System Advisor Model" (SAM) which is available to download on their site (https://sam.nrel.gov). The review and analysis presented by SAM goes more in depth than what's typically provided during the bidding process from vendors for residential installations.

Incentives and Benefits

The benefits for rooftop solar installations in Oregon currently include federal and state tax credits as well as an additional incentive provided by the Energy Trust of Oregon. It's worth noting that incentives for commercial installations differ from those available to residential customers, and are not covered or considered by our analysis.

The greatest incentive is received from the United States federal government, which gives a significant tax credit that covers 30% of qualified expenditures for systems placed in service by 12/31/2019 [1]. As previously mentioned, the state of Oregon offers some tax credits as well [2]. It does this through the State of Oregon Residential Energy Tax Credit Program, which offers a tax credit of $1.30 per watt of installed capacity of direct current, up to $1500 per year for 4 years for the installation of a solar electric (photovoltaic) systems [3].
Energy Trust of Oregon, a nonprofit organization which helps Oregon utility customers make energy efficiency improvements, and encourages adoptions of renewable energy sources [8]

offers $0.35 per watt, up to $2,800 for PGE customers, based on system size [4].
Finally, batteries may be eligible for the same 30% Federal tax credit if used in a qualifying manner, as long as it meets some basic requirements. First the battery must obtain at least 75% of its charge from the installed solar system. Next, the credit is limited by the percentage of solar input. For example, if the battery receives 90 percent of its charge from solar, then it is eligible for 90 percent of the tax credit. [5, 6].

Solar Quote Comparison

The solar customer evaluated by this analysis was given three different quotes on size of system, which are outlined below.

	Estimated Size	Annual Estimated Output	Annual Electric Bill Offset	Estimated new monthly bill	Estimated New annual bill
System 1	3.64 kW	3877 kWh	25%	$104	$1,253
System 2	5.46 kW	5320 kWh	34%	$92	$1,101
System 3	13.78 kW	12561 kWh	75%	$29	$351

Table II. System Size Overview

These three systems were evaluated for cost and incentives. The cost of the system was based on an average all-in cost in Oregon of $3.50/W [39]. The cost of the system after credits was evaluated with the federal and state credits outlined in the above section.

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	State Deduction	Cost After Credits	Cost/kW
System 1	3.64	$12,740	$1,274	$3,440	$4,732	$3,294	$905
System 2	5.46	$19,110	$1,911	$5,160	$6,000	$6,039	$1,106
System 3	13.78	$48,230	$2,800	$13,629	$6,000	$25,801	$1,872

Table III. Cost comparison of various sized systems

As can be seen in these calculations, the maximum benefits are reached at a system size of less than 5.46 kW. When evaluating against how much money can be saved from the electricity bill however, a small system will not cover a significant part of the electricity bill. The solar customer utilized in this study installed a slightly higher system, at 5.98 kW, which ended up with a cost of $7,186, per the calculation below.

Purchased system:
5.98 kW x $0.35/W = $2,093 deduction from the Energy Trust of Oregon
$18,837 x .3 = $5,651 deduction for federal incentives, taken after ETO
5.98 kW x $1.30/W = $7,774 deduction for state incentives, however this is over the maximum, so a $6,000 deduction is utilized

Battery Comparison

Solar compatible battery systems have taken off worldwide. There are tons of companies/startups who sell residential batteries, but for this project we only chose batteries which are available in the United States. Each battery has its own merits and demerits. The table below lets us easily compare costs, capacities etc for solar batteries side to side. Unfortunately, as this technology is relatively new, it was hard to get definitive figures for the number of units sold-to-date in the US. Some batteries are compatible with different inverters for example LG Chem RESU is compatible with SolaX and SunGrow while other batteries are designed to work only with the same brand [28]. Each battery has a different battery type, capacity and power output. All the batteries operate at different temperature. The average operating temperature range for these batteries is -5°C to 45°C [27].

Product Name	Cost	Capacity	Warranty	Total warranted kWh (1 Cycle/day)	Cost/Total Warranted kWh (1 Cycle/day)
Tesla Powerwall 2	$6200	13.5 kWh	10 years	37,800	$0.23
LG Chem Resu 10	$6626	8.8 kWh	10 years	30,000	$0.30
RedFlow Zcell	$9847	10 kWh	10 years	36,500	$0.35
BYD B-Box LV	$6576	9.8 kWh	10 years	35,770	$0.24
Sonnen	$22965	16 kWh	10 years	58,400	$0.52

Table IV. Battery Cost Comparison
https://www.solarquotes.com.au/battery-storage/comparison-table/

The total warranted kWh and cost per warranted kWh is calculated in the table, which may be helpful in determining which battery is most cost effective. The warranted kWh and cost per warranted kWh is calculated because the capacity of the battery degrades with time [28].

Total warranted kWh -- if the battery is only discharged once per day, then the warranty period may expire well before the warranted kWh are all used up[28]. The number of kWh the battery can discharge per day is multiplied by the number of days during the warranty period to get the figures for this row.

Cost per warranted kWh -- the price of the battery divided by 'Warranted kWh (1 cycle per day)'. If the battery is discharged approximately once per day, this number indicates which system may be the most cost effective [28].

There are always pros and cons related to a product, and batteries are no different. To help us better understand the different units, we found and included the following table which lists generally perceived pros and cons each unit/system.

Product	Pros	Cons
Tesla Powerwall 2	Advanced safety features minimise fire risk, extremely competitive price, impressive warranty.	Not yet available.
LG Chem Resu 10	Can be used in both off-grid and hybrid setups, compact size, modular expansion.	Battery is warranted to 45ºC ambient.
RedFlow Zcell	high depth-of-discharge, can tolerate temperatures up to 50 degrees C, easily recyclable.	Requires a maintenance cycle once a week or so that takes the battery offline for a few hours.
BYD B-Box LV	High cycle life, high power output	High power output is limited by solar inverter.
Sonnen	100% DoD, long cycle life, great warranty.	Relatively low power output - max 3kW continuous single phase, Expensive.

Table V. Battery Pros and Cons

https://www.solarquotes.com.au/battery-storage/comparison-table/

Economic Evaluation

Methodology and Assumptions

For the system analysis, we had to expand on the general case assumptions made for a system in the Portland, OR metro area. For system costs, we settled on an installation price of $3.50/Watt based on market research [39], and further assumed that the cost of energy was going to increase by 2.3% per year [7]. From there, we considered our Minimum Acceptable Rate of Return (MARR) to be 7.85% based on the historical S&P 500 returns over the previous 15 years. Meaning that if we were to invest the upfront cost of the system into a mutual fund which tracks the S&P 500 we could expect a return on our investment proportional to that rate.

To estimate the energy consumed over a year period, data was obtained for the last full year of the property in question and then a total amount of energy was determined. For simplicity's sake, we assumed that the energy consumption of the property would neither increase, nor decrease for the life of the system, which was guaranteed by the installer at 20 years. This gave us a nominal system generation of 5,185.26 kWh, and a total consumption figure of 9,589.03 kWh. Furthermore, we assumed that system generation would continue at this level throughout the life of the system because it was warrantied. Base connection costs charged by the regional Utility (to connect to, and maintain the grid) are unavoidable, and total $136.08 per year.

As previously mentioned, rooftop solar arrays are generally sighted on the south facing side of the roof so as to capture the maximum amount of energy as the sun passes through the sky. Since our property had plentiful space on the south-facing roof, we assumed that all systems we considered would fit on the south-facing side like the proposed 5.98 kWh system we used as our base. Finally, the cost of energy in the Portland metro at the time of this writing is $0.115 per kilowatt hour, however our customer was already enrolled in Portland General Electric's Green Source program which contained energy produced through renewable utility-scale sources, such as hydro, wind, solar, biomass and geothermal. Green Source increased the price per kilowatt hour to a total of $0.1228 per kilowatt hour [6].

Size of system (kW)	5.98
Flat utility fee/year ($)	136.08
Cost ($/ kWh)	0.1228
Generation/year (kWh)	5185.26
Consumption/year (kWh)	9589.03
Electricity Rate Increase/Year (%)	2.30%

MARR (%)	7.85%

Table VI. Summary of utilized factors in the analysis.

Once we had production factors like system size and cost, kWh generation numbers per month for a year, and billing practices we were able to confidently adjust aspects to estimate what factors may have largest impacts on generation. We were able to create cash flows for 20 years on a yearly basis using our determined numbers from the data gathering, and find the internal rate of return (IRR) and net present value (NPV) of the investment. We also calculated the straight payback period, since we considered only purchasing options for systems rather than leasing.

Once we completed the base analysis, we then scaled each factor independently to see how much the system was affected. We chose to review 25% increases and decreases both in energy consumption, system size, system generation, and power rate increases. We compared and modified the inputs to determine the ideal system size based on today's incentive programs, power rates, location, and solar production in this region.

Some specific assumptions and discoveries were made here, which included constant power rate increases, as well as no changes in future energy laws. Due to net metering rules, a system that annually generated more than it consumed was not advised, as there was no additional credit received for the power generated, so a significantly larger system was not analyzed.

Base System Evaluation

As outlined above, an average installation cost was used to determine the upfront cost of the system. It was determined that the federal and ETO rebates were given up front to the customer, and the state rebate was taken over a four year period. This gives an installation cost of $13,186, as shown below.

	Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System After Tax Credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Table VII. Base System Upfront Cost

To create our 20 year cash flow with solar, we added consumption and generation to get a net usage. This was then compared to the straight consumption value, which was the theoretical cost without solar, to get a number of savings. The state credit was considered for the first four years.

Year	Cost	State	Net	Utility Cost of	Cost w/o	Savings ($)

		Credit	Usage (kWh)	Electricity w/ Solar ($)	solar per year ($)	
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$676.76	$1,313.38	$2,136.63
2		$1,500.00	4403.77	$692.32	$1,343.59	$2,151.27
3		$1,500.00	4403.77	$708.25	$1,374.49	$2,166.25
4		$1,500.00	4403.77	$724.54	$1,406.11	$2,181.57
5			4403.77	$741.20	$1,438.45	$697.25
6			4403.77	$758.25	$1,471.53	$713.28
7			4403.77	$775.69	$1,505.38	$729.69
8			4403.77	$793.53	$1,540.00	$746.47
9			4403.77	$811.78	$1,575.42	$763.64
10			4403.77	$830.45	$1,611.65	$781.20
11			4403.77	$849.55	$1,648.72	$799.17
12			4403.77	$869.09	$1,686.64	$817.55
13			4403.77	$889.08	$1,725.44	$836.36
14			4403.77	$909.53	$1,765.12	$855.59
15			4403.77	$930.45	$1,805.72	$875.27
16			4403.77	$951.85	$1,847.25	$895.40
17			4403.77	$973.74	$1,889.74	$916.00
18			4403.77	$996.14	$1,933.20	$937.06
19			4403.77	$1,019.05	$1,977.66	$958.62
20			4403.77	$1,042.49	$2,023.15	$980.67

Table VIII. Base Evaluation 20 Year Cash Flow

Based on this cash flow, the IRR was determined over various periods of the lifetime, and the NPV, considering our comparison to the MARR. The payback period we found aligns with the

IRR, in that within year 10 you break even and from that point on you start to make money. However, even though the system is making money after the 10 year mark, it's not as much money as one could obtain by investing it into an S&P 500 index fund, which is why the NPV is displayed as negative.

IRR - 5 year	-12%
NPV - 5 year	($5,538.17)

IRR - 10 year	0%
NPV - 10 year	($3,493.45)

IRR - 15 year	5%
NPV - 15 year	($1,923.41)

IRR - 20 year	7%
NPV - 20 year	($717.85)

Payback period	Year 11

Table IX. Economic Analysis of Base System

These results show that installing a solar system in Hillsboro can be a sound economic decision, depending on how long someone is planning on staying in the same house. If the goal is to minimize one's impact, and be more ecologically friendly, then installing solar is very much justified. However, if the goal is to make the greatest return on your investment, than taking that money and placing it in into a mutual fund may be a better option.

Sensitivity Analysis

After analyzing the base case, we then looked at the various assumptions we made and factors that were used in the analysis: *consumption*, *current electricity rate*, *electricity rate increase over time*, and *size of system*. Each of these detailed cash flows can be found in the appendices.

We found that varying the consumption (Appendix D and E) did not have an effect on the rate of return or net present value. This is because both the cost without solar and cost with solar were scaled by the same amount, so the amount saved was the same.

Both the current electricity rate (Appendix J and I), and electricity rate increase (Appendix F and G) affected the rate of return and present value of the system. By increasing the current electricity rate by 25%, the IRR of the system over its 20 year life increased to 9% and the system is paid back two years sooner. By increasing the forecasted electricity rate increase 25%, the overall IRR was around the same, but the net present value went up, making the option of installing solar more even with investing. Decreasing both the current rate and rate increase had an adverse effect on the economic value.

By adjusting the purchased solar system size (Appendix B and C), it was determined there was a sweet spot for maximizing the tax credits and getting the most energy. Because the state tax credit has a maximum of $6,000, the most cost efficient size is just under 5 kW. With a system size of 4.485 kW, the rate of return at the end of the 20 years was 12% and the payback period was the soonest at 7 years. These results show how closely tied the economic benefits are to the tax credits themselves.

IRR - 5 year	-3%
NPV - 5 year	($2,382.51)

IRR - 10 year	7%
NPV - 10 year	($337.80)

IRR - 15 year	11%
NPV - 15 year	$1,232.24

IRR - 20 year	12%
NPV - 20 year	$2,437.80

Payback period	Year 7

Table X. Results for 4.485 kW system.

Overall, the sensitivity analysis shows that in general, you can make your money back from purchasing a solar system, but it may take a while. It shows that the economic value of the system will differ greatly across the United States because of the state incentives and the varying electricity rates. It’s difficult to predict what will happen with electricity rates and what the future of net metering will be, but in general, Oregon enjoys fairly low electricity rates due to the network of dams and constant wind in the eastern part of the state. The analysis shows a baseline for this, and that in other parts of the country, where electricity is more expensive, solar will have a faster payback period and higher rate of return.

The analysis completed will depend heavily on net metering laws. There are cases where excess generation cannot be netted for energy use at a different time of day, as this evaluation does, or that the utility will pay different rates for generated power at different times of the day, or where they charge you different rates for consumption at different times of the day. This is where the possibility of a battery starts to become a key decision.

Battery Option

In Oregon, solar power buyback agreements include a net metering contract, which essentially means any kWh you generate beyond consumption in a hour/day/month or period are “stored” as credit for your later use. This means that generation kWh value is the same as consumption, and thus there is no benefit to storing the power in a battery. With net metering rules, if you generate 50 kWh more than you consume each month, you are are still paying the fees to deliver the power and have a connected system. In some cases, through PGE in the Pacific Northwest, and PG&E in California, you have the ability to sell power back to the utility at a much lower rate than the one you pay. This means that if you are generating more than you consume every month, you could actually be paid by the power company and that could cover your fees or exceed them. Having a battery would mean that the solar power you are generating is more valuable if you store it rather than the utility, which is not true in our case in Oregon. PGE in Oregon will pay anywhere from $.019/kWh to .032/kWh [37], which at best case is 33% of the value of a purchased kWh -- thus there is no economic benefits to installing a battery system. However, non-economic benefits could be worthwhile, and should be considered. As mentioned above, mitigating brownouts or blackouts could have numerous benefits. Below is a sample of the number of power outages by region for 2008 - 2013.

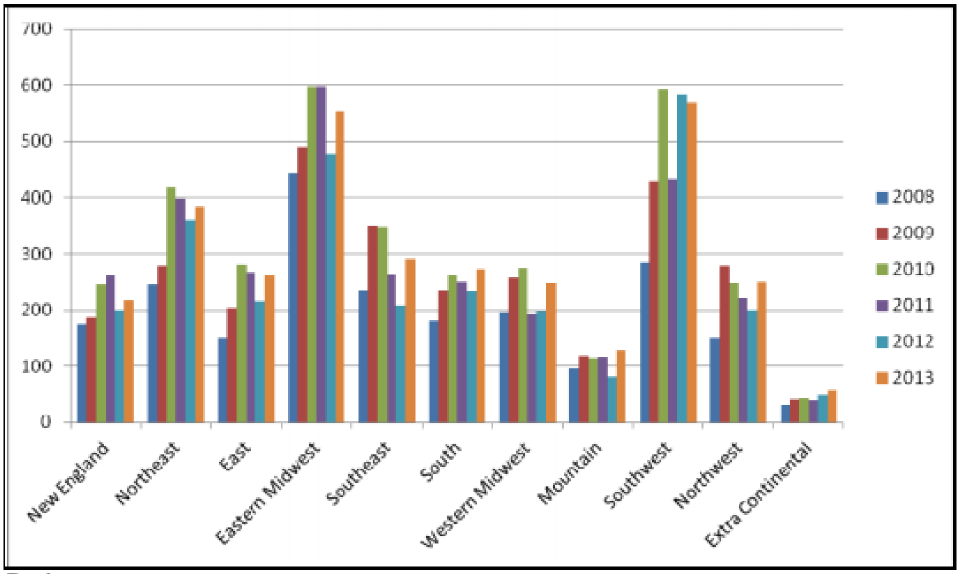

Figure I. Power Outages reported by region [38]

Future Trends

MIT research on solar energy concluded that solar electricity generation will continue to grow, as it is one of best low-carbon energy technologies available today. The MIT researchers expect solar energy to generate on a multi-terawatt scale in the future [35]. Prices of solar panels are decreasing, and the number of solar panel installations are increasing [36]. Figure II shows that growth of solar energy based on the solar panel installations and its cost. Technology advancements in solar cell will further make it more efficient. The cost will also continue to decrease when technology breakthrough happens. The advantages like reduction in global warming, cost benefit, energy reliability, energy security and energy interdependence influence the growth of solar power. Figure III shows the growth forecast of solar power [37].

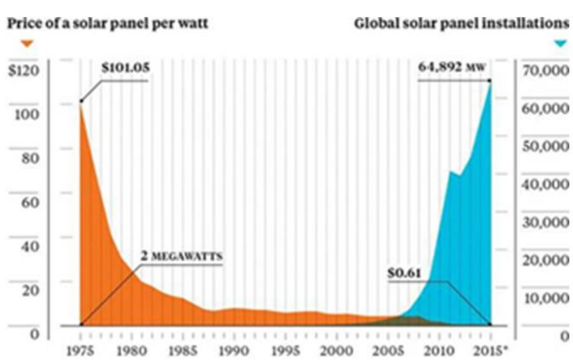

Figure II. Solar Panel Installations [36]

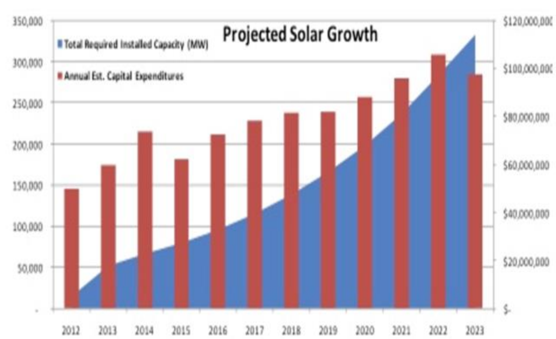

Figure III Projected Solar Growth [37]

The primary driver for residential solar power in the US is the federal solar investment tax credit (ITC). Net metering plays a significant role in local solar energy growth as well. It credits the owner for the electricity they add to the grid because most customers don't use the energy generated completely. Exported solar energy serves other customers. Net metering reduces the customer's electricity bill. There is growth in number of net metered customers as well.

The current standard of residential solar plus storage is expected to elevate because of the integration of generation, storage and energy management into single systems. In the future, homes are expected to have an integrated solar and storage system, networked appliances and electric vehicles (EV). All these systems are expected to be connected to a monitoring and control system. This network allows higher level of renewable energy to support the grid. IHS, a market research firm said energy storage market installed 0.34 GW in 2012-2013. They estimated the annual installation size to be 6 GW in 2017 and 40 GW in 2022. Solar plus storage is expected to be broadly adopted after the availability of smart battery that can handle load shifting, backup power application and demand response. Currently battery systems are behind solar panels. The competitors in battery storage system are Tesla and Sonnen. Battery system is expected to be the future of solar. It eliminates the net metering stress as it is independent of the power company. The power stored can be used during power outage and during natural disasters. They can also share the excess power with their neighbors [33].

Conclusion

Evaluating the economic value of home solar power systems will naturally depend on the size of the system installed, as size directly affects cost. Additionally, due to the various government incentives available to Portland residents, smaller systems have better NPV and IRR, while batteries do not provide an economic benefit (although batteries do provide other benefits outside the scope of this paper). The highest NPV and IRR systems tended to be the sized equivalent to limit of government incentives.

Thus purchasing larger systems can easily push the NPV values into negatives over the 20 year expected life. For example, the absence of time-of-day electricity pricing in Portland removes some benefits that would otherwise be felt in other parts of the country with peak use rates. Adding solar to a house and maintaining it for a longer period of time is an average investment. With the lifetime of solar systems typically being greater than 10 years, consumers can see an IRR roughly equal to that of the S&P 500. We stress that if electricity costs increase at a higher rate than the 2.3% assumed we assumed in our calculations, the benefits of investing in solar increase.

Our analysis shows that the best option in-and-around Portland, OR is to install a solar system of approximately 5kWh and forego the battery. Individuals looking to maximize these benefits should install a system soon, as benefits are tightly tied to government incentives which are currently scheduled to decrease starting in 2020, with federal tax credits being completely eliminated starting in 2022.

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Appendices

Appendix A
Base System Calculation

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$676.76	$1,313.38	$2,136.63
2		$1,500.00	4403.77	$692.32	$1,343.59	$2,151.27
3		$1,500.00	4403.77	$708.25	$1,374.49	$2,166.25
4		$1,500.00	4403.77	$724.54	$1,406.11	$2,181.57
5			4403.77	$741.20	$1,438.45	$697.25
6			4403.77	$758.25	$1,471.53	$713.28
7			4403.77	$775.69	$1,505.38	$729.69
8			4403.77	$793.53	$1,540.00	$746.47
9			4403.77	$811.78	$1,575.42	$763.64
10			4403.77	$830.45	$1,611.65	$781.20
11			4403.77	$849.55	$1,648.72	$799.17
12			4403.77	$869.09	$1,686.64	$817.55
13			4403.77	$889.08	$1,725.44	$836.36
14			4403.77	$909.53	$1,765.12	$855.59
15			4403.77	$930.45	$1,805.72	$875.27
16			4403.77	$951.85	$1,847.25	$895.40
17			4403.77	$973.74	$1,889.74	$916.00
18			4403.77	$996.14	$1,933.20	$937.06
19			4403.77	$1,019.05	$1,977.66	$958.62
20			4403.77	$1,042.49	$2,023.15	$980.67

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

IRR - 5 year	-12%
NPV - 5 year	($5,538.17)

IRR - 10 year	0%
NPV - 10 year	($3,493.45)

IRR - 15 year	5%
NPV - 15 year	($1,923.41)

IRR - 20 year	7%
NPV - 20 year	($717.85)

Payback period	Year 11

Appendix B
+25% Sized System

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	7.475	$26,163	$2,616	$7,064	$16,482

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1.25	7.475
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$16,482.38					-$16,482.38
1		$1,500.00	4403.77	$676.76	$1,313.38	$2,136.63
2		$1,500.00	4403.77	$692.32	$1,343.59	$2,151.27
3		$1,500.00	4403.77	$708.25	$1,374.49	$2,166.25
4		$1,500.00	4403.77	$724.54	$1,406.11	$2,181.57
5			4403.77	$741.20	$1,438.45	$697.25
6			4403.77	$758.25	$1,471.53	$713.28
7			4403.77	$775.69	$1,505.38	$729.69
8			4403.77	$793.53	$1,540.00	$746.47
9			4403.77	$811.78	$1,575.42	$763.64
10			4403.77	$830.45	$1,611.65	$781.20
11			4403.77	$849.55	$1,648.72	$799.17
12			4403.77	$869.09	$1,686.64	$817.55
13			4403.77	$889.08	$1,725.44	$836.36
14			4403.77	$909.53	$1,765.12	$855.59
15			4403.77	$930.45	$1,805.72	$875.27
16			4403.77	$951.85	$1,847.25	$895.40
17			4403.77	$973.74	$1,889.74	$916.00
18			4403.77	$996.14	$1,933.20	$937.06
19			4403.77	$1,019.05	$1,977.66	$958.62
20			4403.77	$1,042.49	$2,023.15	$980.67

IRR - 5 year	-18%
NPV - 5 year	($8,834.64)

IRR - 10 year	-5%
NPV - 10 year	($6,789.92)

IRR - 15 year	1%
NPV - 15 year	($5,219.88)

IRR - 20 year	4%
NPV - 20 year	($4,014.33)

Payback period	Year 15

Appendix C
-25% Sized System

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	4.485	$15,698	$1,570	$4,238	$9,889

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	0.75	4.485
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$9,889.43					-$9,889.43
1		$1,457.63	4403.77	$676.76	$1,313.38	$2,094.25
2		$1,457.63	4403.77	$692.32	$1,343.59	$2,108.89
3		$1,457.63	4403.77	$708.25	$1,374.49	$2,123.87
4		$1,457.63	4403.77	$724.54	$1,406.11	$2,139.20
5			4403.77	$741.20	$1,438.45	$697.25
6			4403.77	$758.25	$1,471.53	$713.28
7			4403.77	$775.69	$1,505.38	$729.69
8			4403.77	$793.53	$1,540.00	$746.47
9			4403.77	$811.78	$1,575.42	$763.64
10			4403.77	$830.45	$1,611.65	$781.20
11			4403.77	$849.55	$1,648.72	$799.17
12			4403.77	$869.09	$1,686.64	$817.55
13			4403.77	$889.08	$1,725.44	$836.36
14			4403.77	$909.53	$1,765.12	$855.59
15			4403.77	$930.45	$1,805.72	$875.27
16			4403.77	$951.85	$1,847.25	$895.40
17			4403.77	$973.74	$1,889.74	$916.00
18			4403.77	$996.14	$1,933.20	$937.06
19			4403.77	$1,019.05	$1,977.66	$958.62
20			4403.77	$1,042.49	$2,023.15	$980.67

IRR - 5 year	-3%
NPV - 5 year	($2,382.51)
IRR - 10 year	7%
NPV - 10 year	($337.80)
IRR - 15 year	11%
NPV - 15 year	$1,232.24
IRR - 20 year	12%
NPV - 20 year	$2,437.80
Payback period	Year 7

Appendix D
+25% Consumption

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1.25	11986.288
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	6801.03	$971.08	$1,607.71	$2,136.63
2		$1,500.00	6801.03	$993.42	$1,644.69	$2,151.27
3		$1,500.00	6801.03	$1,016.27	$1,682.51	$2,166.25
4		$1,500.00	6801.03	$1,039.64	$1,721.21	$2,181.57
5			6801.03	$1,063.55	$1,760.80	$697.25
6			6801.03	$1,088.01	$1,801.30	$713.28
7			6801.03	$1,113.04	$1,842.73	$729.69
8			6801.03	$1,138.64	$1,885.11	$746.47
9			6801.03	$1,164.83	$1,928.47	$763.64
10			6801.03	$1,191.62	$1,972.82	$781.20
11			6801.03	$1,219.03	$2,018.20	$799.17
12			6801.03	$1,247.06	$2,064.62	$817.55
13			6801.03	$1,275.75	$2,112.10	$836.36
14			6801.03	$1,305.09	$2,160.68	$855.59
15			6801.03	$1,335.10	$2,210.38	$875.27
16			6801.03	$1,365.81	$2,261.21	$895.40
17			6801.03	$1,397.23	$2,313.22	$916.00
18			6801.03	$1,429.36	$2,366.43	$937.06
19			6801.03	$1,462.24	$2,420.85	$958.62
20			6801.03	$1,495.87	$2,476.53	$980.67

IRR - 5 year	-12%
NPV - 5 year	($5,538.17)
IRR - 10 year	0%
NPV - 10 year	($3,493.45)
IRR - 15 year	5%
NPV - 15 year	($1,923.41)
IRR - 20 year	7%
NPV - 20 year	($717.85)
Payback period	Year 11

Appendix E
-25% Consumption

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	2006.51	$382.43	$1,019.06	$2,136.63
2		$1,500.00	2006.51	$391.23	$1,042.50	$2,151.27
3		$1,500.00	2006.51	$400.23	$1,066.47	$2,166.25
4		$1,500.00	2006.51	$409.43	$1,091.00	$2,181.57
5			2006.51	$418.85	$1,116.09	$697.25
6			2006.51	$428.48	$1,141.76	$713.28
7			2006.51	$438.34	$1,168.03	$729.69
8			2006.51	$448.42	$1,194.89	$746.47
9			2006.51	$458.73	$1,222.37	$763.64
10			2006.51	$469.28	$1,250.49	$781.20
11			2006.51	$480.08	$1,279.25	$799.17
12			2006.51	$491.12	$1,308.67	$817.55
13			2006.51	$502.41	$1,338.77	$836.36
14			2006.51	$513.97	$1,369.56	$855.59
15			2006.51	$525.79	$1,401.06	$875.27
16			2006.51	$537.88	$1,433.29	$895.40
17			2006.51	$550.26	$1,466.25	$916.00
18			2006.51	$562.91	$1,499.98	$937.06
19			2006.51	$575.86	$1,534.48	$958.62
20			2006.51	$589.10	$1,569.77	$980.67

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	0.75	7191.7725
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

IRR - 5 year	-12%
NPV - 5 year	($5,538.17)
IRR - 10 year	0%
NPV - 10 year	($3,493.45)
IRR - 15 year	5%
NPV - 15 year	($1,923.41)
IRR - 20 year	7%
NPV - 20 year	($717.85)

Payback period	Year 11

Appendix F
+25% Rate Increase

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$676.76	$1,313.38	$2,136.63
2		$1,500.00	4403.77	$696.21	$1,351.14	$2,154.93
3		$1,500.00	4403.77	$716.23	$1,389.99	$2,173.76
4		$1,500.00	4403.77	$736.82	$1,429.95	$2,193.13
5			4403.77	$758.01	$1,471.06	$713.06
6			4403.77	$779.80	$1,513.35	$733.56
7			4403.77	$802.22	$1,556.86	$754.65
8			4403.77	$825.28	$1,601.62	$776.34
9			4403.77	$849.01	$1,647.67	$798.66
10			4403.77	$873.42	$1,695.04	$821.62
11			4403.77	$898.53	$1,743.77	$845.24
12			4403.77	$924.36	$1,793.91	$869.55
13			4403.77	$950.94	$1,845.48	$894.54
14			4403.77	$978.28	$1,898.54	$920.26
15			4403.77	$1,006.40	$1,953.12	$946.72
16			4403.77	$1,035.33	$2,009.27	$973.94
17			4403.77	$1,065.10	$2,067.04	$1,001.94
18			4403.77	$1,095.72	$2,126.47	$1,030.75
19			4403.77	$1,127.22	$2,187.60	$1,060.38
20			4403.77	$1,159.63	$2,250.50	$1,090.86

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1.25	2.88%
MARR			7.85%

IRR - 5 year	-11%
NPV - 5 year	($5,509.66)

IRR - 10 year	0%
NPV - 10 year	($3,384.31)

IRR - 15 year	5%
NPV - 15 year	($1,705.98)

IRR - 20 year	7%
NPV - 20 year	($380.64)

Payback period	Year 10

Appendix G
-25% Rate Increase

	Estimated Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System after tax credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$676.76	$1,313.38	$2,136.63
2		$1,500.00	4403.77	$688.43	$1,336.04	$2,147.61
3		$1,500.00	4403.77	$700.31	$1,359.09	$2,158.78
4		$1,500.00	4403.77	$712.39	$1,382.53	$2,170.14
5			4403.77	$724.68	$1,406.38	$681.70
6			4403.77	$737.18	$1,430.64	$693.46
7			4403.77	$749.89	$1,455.32	$705.42
8			4403.77	$762.83	$1,480.42	$717.59
9			4403.77	$775.99	$1,505.96	$729.97
10			4403.77	$789.37	$1,531.94	$742.56
11			4403.77	$802.99	$1,558.36	$755.37
12			4403.77	$816.84	$1,585.24	$768.40
13			4403.77	$830.93	$1,612.59	$781.66
14			4403.77	$845.27	$1,640.41	$795.14
15			4403.77	$859.85	$1,668.70	$808.86
16			4403.77	$874.68	$1,697.49	$822.81
17			4403.77	$889.77	$1,726.77	$837.00
18			4403.77	$905.12	$1,756.56	$851.44
19			4403.77	$920.73	$1,786.86	$866.13
20			4403.77	$936.61	$1,817.68	$881.07

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1	0.122776
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	0.75	1.73%
MARR			7.85%

IRR - 5 year	-12%
NPV - 5 year	($5,566.37)

IRR - 10 year	-1%
NPV - 10 year	($3,599.52)

IRR - 15 year	4%
NPV - 15 year	($2,131.25)

IRR - 20 year	6%
NPV - 20 year	($1,035.16)

Payback period	Year 11

Appendix H
+25% Current Electricity Rate

	Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System After Tax Credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$811.93	$1,607.71	$2,295.78
2		$1,500.00	4403.77	$830.60	$1,644.69	$2,314.08
3		$1,500.00	4403.77	$849.71	$1,682.51	$2,332.81
4		$1,500.00	4403.77	$869.25	$1,721.21	$2,351.96
5			4403.77	$889.24	$1,760.80	$871.56
6			4403.77	$909.69	$1,801.30	$891.60
7			4403.77	$930.62	$1,842.73	$912.11
8			4403.77	$952.02	$1,885.11	$933.09
9			4403.77	$973.92	$1,928.47	$954.55
10			4403.77	$996.32	$1,972.82	$976.51
11			4403.77	$1,019.23	$2,018.20	$998.96
12			4403.77	$1,042.67	$2,064.62	$1,021.94
13			4403.77	$1,066.66	$2,112.10	$1,045.45
14			4403.77	$1,091.19	$2,160.68	$1,069.49
15			4403.77	$1,116.29	$2,210.38	$1,094.09
16			4403.77	$1,141.96	$2,261.21	$1,119.25
17			4403.77	$1,168.23	$2,313.22	$1,145.00
18			4403.77	$1,195.10	$2,366.43	$1,171.33
19			4403.77	$1,222.58	$2,420.85	$1,198.27
20			4403.77	$1,250.70	$2,476.53	$1,225.83

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	1.25	0.15347
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

IRR - 5 year	-9%
NPV - 5 year	($4,872.44)

IRR - 10 year	3%
NPV - 10 year	($2,316.54)

IRR - 15 year	7%
NPV - 15 year	($353.99)

IRR - 20 year	9%
NPV - 20 year	$1,152.96

Payback period	Year 9

Appendix I

-25% Current Electricity Rate

	Size (kW)	Estimated Cost of System	ETO Deduction	Federal Deduction	Cost of System After Tax Credits
System	5.98	$20,930	$2,093	$5,651	$13,186

Year	Cost	State Credit	Net Usage (kWh)	Utility Cost of Electricity w/ Solar ($)	Cost w/o solar per year ($)	Savings ($)
0	$13,185.90					-$13,185.90
1		$1,500.00	4403.77	$541.59	$1,019.06	$1,977.47
2		$1,500.00	4403.77	$554.04	$1,042.50	$1,988.45
3		$1,500.00	4403.77	$566.79	$1,066.47	$1,999.69
4		$1,500.00	4403.77	$579.82	$1,091.00	$2,011.18
5			4403.77	$593.16	$1,116.09	$522.93
6			4403.77	$606.80	$1,141.76	$534.96
7			4403.77	$620.76	$1,168.03	$547.27
8			4403.77	$635.04	$1,194.89	$559.85
9			4403.77	$649.64	$1,222.37	$572.73
10			4403.77	$664.58	$1,250.49	$585.90
11			4403.77	$679.87	$1,279.25	$599.38
12			4403.77	$695.51	$1,308.67	$613.16
13			4403.77	$711.50	$1,338.77	$627.27
14			4403.77	$727.87	$1,369.56	$641.69
15			4403.77	$744.61	$1,401.06	$656.45
16			4403.77	$761.73	$1,433.29	$671.55
17			4403.77	$779.25	$1,466.25	$687.00
18			4403.77	$797.18	$1,499.98	$702.80
19			4403.77	$815.51	$1,534.48	$718.96
20			4403.77	$834.27	$1,569.77	$735.50

Value	Base Value	Scaling Factor	Scaled Value
Base size of system	5.98	1	5.98
Flat Utility fee/year	136.08	1	136.08
Cost $/ kWh	0.122776	0.75	0.092082
Generation/year (kWh)	5185.258	1	5185.258
Consumption/year (kWh)	9589.03	1	9589.03
Electricity Rate Increase/Year	2.30%	1	2.30%
MARR			7.85%

IRR - 5 year	-15%
NPV - 5 year	($6,203.90)

IRR - 10 year	-4%
NPV - 10 year	($4,670.36)

IRR - 15 year	2%
NPV - 15 year	($3,492.83)

IRR - 20 year	4%
NPV - 20 year	($2,588.66)

Payback period	Year 14