Pacific Northwest Residential PV Implementation Study

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1. Introduction

1.1 Business Model

As a group of people working under a well-developed company, we are looking for opportunities to help the company gain profit. Considering a sufficient amount of company asset that we are able to have control with, we summarized a business plan to implement residential photovoltaic system in the Pacific Northwest area.

Under this business model, we will select a residential area as target location, and then we will deploy service and offer to residences in the area to rent their roof and install Photovoltaic (PV) system at their roof. In return, to the customers, we will pay rent according to the size of PV system they are capable to install. From this project, the company will be able to profit from selling generated electricity and tax reductions.

1.2 Problem Definition

Although the core focus of this study is profitability of the business model, there are other key questions outside of the financial stability that need to be answered first. For example, how much electricity can we generate? How much can we earn from selling electricity? How many customers do we need to participate in order to generate sufficient amount of electricity to make profit? What polices and regulations do we need to be concerned with? What is the market situation to implement such project? How to maximize the profit? Etc.

With all these concerns, this Pacific Northwest Residential PV Implementation Study is constructed to determine the feasibility for the business model and obtain a better understanding of the present renewable energy market.

In addition to the uncertainly of the current market situation, one main apprehension is the return period for the project. Considering to the immense amount of initial investment the project requires, we are uncertain about the return period. Therefore, we would like to obtain an approximate return period for the project to determine if it is still acceptable. In conclusion, it summarized to two main question.

1. Is this new business model profitable?
2. How long is the return period for the new business model to be profitable?

2. Marketing Analysis

2.1 Market Need

In order to understand the market analysis, we need to understand what kind of needs PV serves. PV implementation essentially encompasses three major needs.

Decrease Energy Reliance: With the implementation of sustainable and renewable energy which is one of the best alternative of costly energy providers. As the source of energy is Sun which never increases its rates as opposed to utility provider. Residential electricity prices are more expensive than industrial, commercial and all other sectors, which you are able to sell your additional energy back to the grid.

Decrease Energy Bills: There is an average of 3.2% increase in residential electricity prices. It is wise to consider solar, if this trend continues.

Improve Environment: If a solar system is implemented it can offset 178 tons of carbon dioxide (CO_2) over a period of 30 years. The energy generated by oil and coal, currently has the major dependency which contributes to major dependency. Solar energy is energy produced from a source that does not harm the environment unlike, fossil fuels that destroy the ozone layer. Ozone layer protects ice caps from melting. [1]

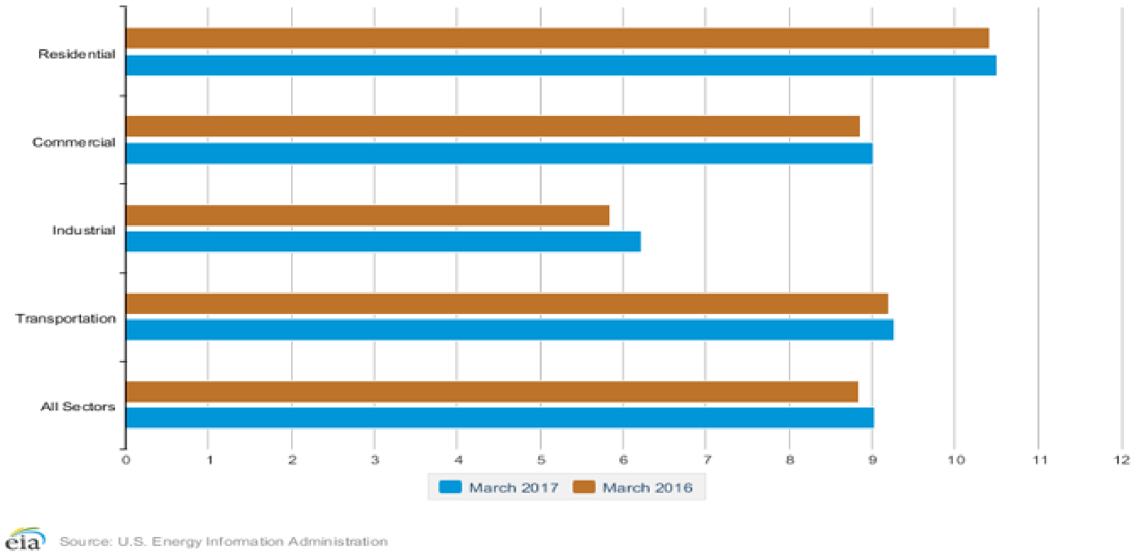

Figure 1: Average Price of Electricity to Ultimate Customers by End-use Sector, 2016-2017

2.2 Market Growth

The market for PV installation has been increasing over the years. Residential PV installation is seen to be increasing each year [2]. The residential market has quarterly incremental growth and continued its steady [3]. Portland is ranked amongst the top 20 cities in the United States open for solar business and installation. The Legislature is debating on solar policies that critical for the growth of solar in the state. RETC (Residential Energy Tax Credit). According to U.S Department of Energy, Portland is solar leader. It uses less than 2% of its solar potential. Cities that are more energy users with high volume of unutilized roof space which are suitable for Solar. [4] According to solar energy industries association, the state ranks fourth in the country for solar output [5]. Another major factor in the growth of the solar market is due to decrease in the price of the solar. According to National Renewable Energy laboratory, the price of solar has been decreasing over the years. Figure 1 shows the cost of solar in the year 2009 was $7.06/ watt which is decreased to 2.93/watt in 2016. [6]

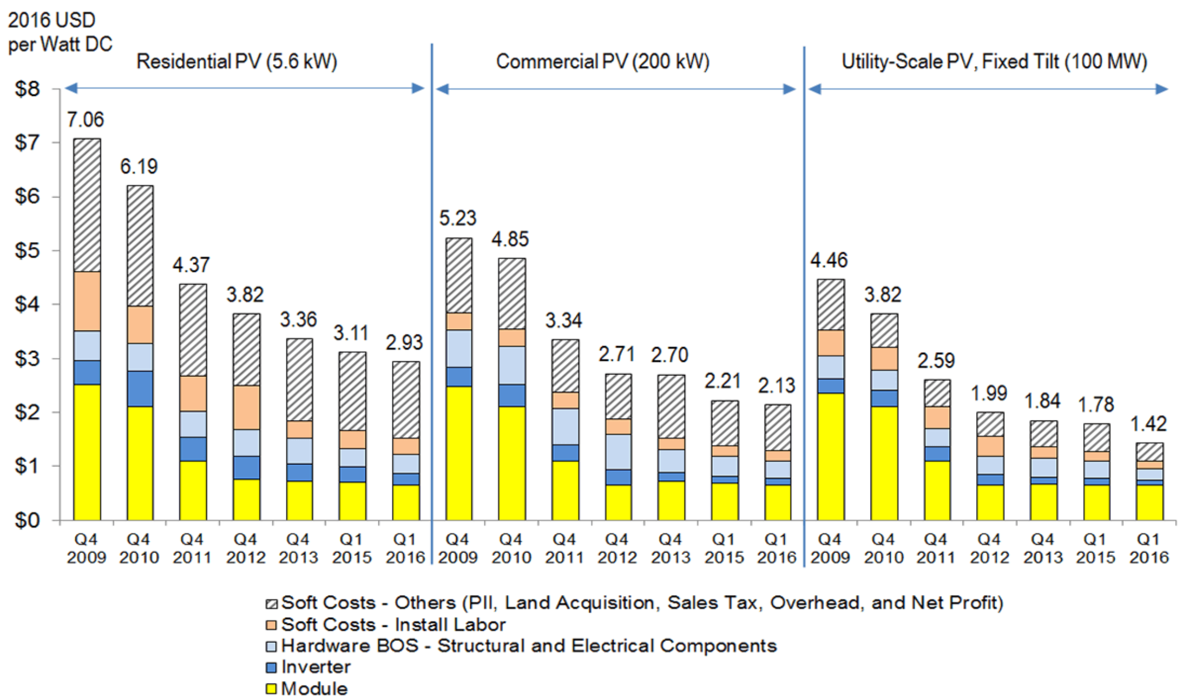

Figure 2: 2016 PV cost per Watt Production

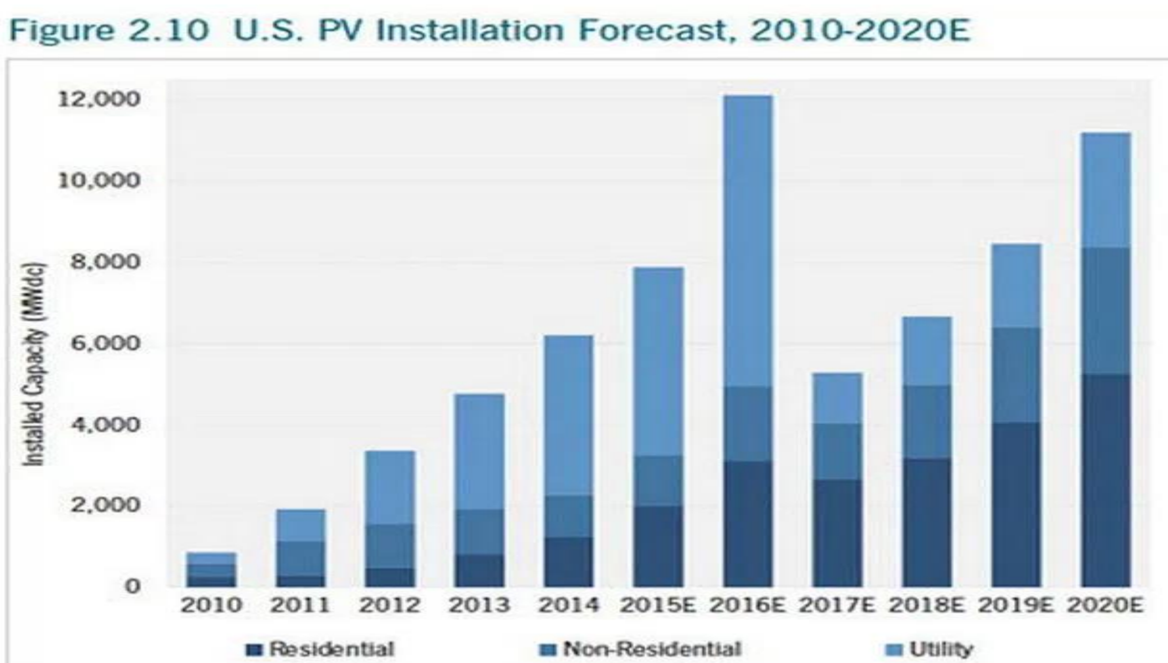

Figure 3: U.S. PV Installation Capacity Forecast 2010-2020

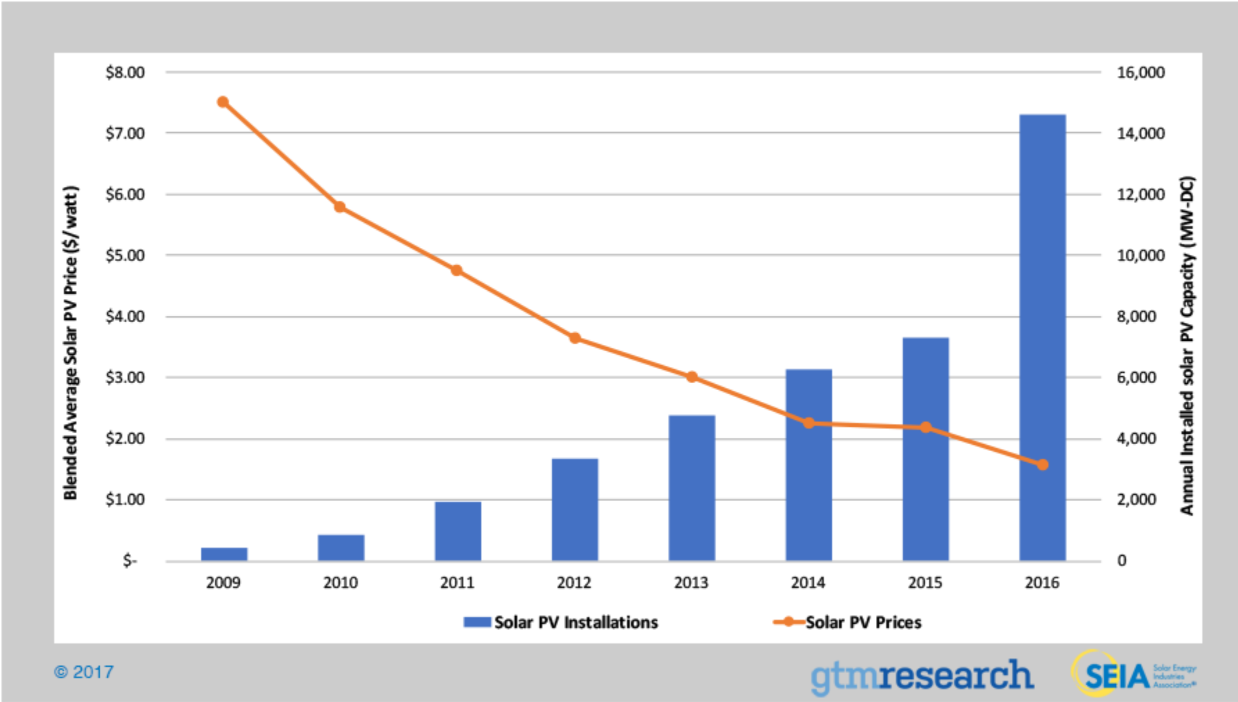

Figure 4: Average Solar PV Price per Watt & Installed Solar PV Capacity, 2009-2016

3. Policies and Incentives (Oregon)

Below is important information about the public policy, rules, and economic reasons that affect your ability to go solar here in Oregon:

Some primary code issues that impact rooftop PV installations include:

- Restrictive or ambiguous language written into the codes;
- Lag time between the release of updated model codes and new PV industry best practices and the widespread adoption of the codes and best practices;
- Variation across jurisdictions in which code editions and amendments are adopted;
- Inconsistent, inefficient, or improper enforcement of codes.

3.1 Building Codes

The current versions of the International Residential Code and the International Building Code require rack-mounted rooftop PV systems to be installed according to the manufacturer's instructions, the National Electrical Code, and Underwriters Laboratories product safety standards [such as UL 1703 (PV modules) and UL 1741 (Inverters)], which are design requirements and testing specifications for PV related equipment safety.

The International Residential Code also requires that:

- The roof is structurally capable of supporting the load of the modules and racking;
- The modules and racking be non-combustible; and
- Roof or wall penetrations (such as to attach the racking to the roof) be flashed and sealed to prevent water, rodents, or insects from entry.

The International Building Code also:

- Requires that rooftop solar systems have the same fire classification as the roof assembly;
- Establishes criteria for calculating the minimum design loads for rooftop solar PV systems, including guidance on wind load engineering calculations.

Fire Codes: Fire codes can address the location of rooftop PV systems, in order to minimize tripping and electrocution hazards and to provide first responders access to roof space. Firefighters can require access to the roof during a fire, especially for the purpose of vertical ventilation (i.e., making a hole in the roof in order to allow heated gas and smoke to escape from the building). IFC provides an exception to roof ridge clearance requirements where an alternative ventilation method approved by the chief is provided or where the chief determines that vertical ventilation techniques would not be required.

Electrical Codes: National Electrical Code (NEC) provides comprehensive electrical safety design, installation, and inspection requirements for electrical conductors, equipment, and raceways related to a solar PV system. NEC, also called the NFPA 70 is developed by the National Fire Protection Association (NFPA) and updated every three years. NEC 2014 has been adopted by 35 states as of October 2016.30. In some states, however, local jurisdictions have primary or complete authority over electrical code adoption.31. NEC devotes two of its articles to addressing solar PV systems: Article 690 (Solar Electric Systems) an Article 705 (Interconnected Electrical)

Planning and Zoning: Zoning regulations can significantly impact where and how solar development can occur in a community. Critical components of zoning regulations related to rooftop PV systems include height restrictions and setbacks, applicability of these restrictions to PV systems, and whether additional permits or zoning variances are needed to install a PV system. Zoning ordinances and building codes often require that structures meet specific minimum setbacks from property lines or that rooftop equipment (such as PV panels) be set back from the edge of the roof. Similarly, building height regulations restrict the height of development for specific types of buildings and structures. Some of these ordinances may unnecessarily apply to PV installations and impose unintended burdens on solar development goals.

3.2 Permit

Portland worked with Energy Trust, solar installers, Oregon SolarEnergy Industries Association, and city staff to develop and implement improvements to city permitting processes. In late 2008, the city's Bureau of Development Services (BDS) put into place a prescriptive residential permitting system. This allowed simple, conforming residential installations to receive combined permits without engineering documents. Once the process was finalized, BDS published program guides to help educate installers and its own staff about the new permitting process and requirements [7]. In addition, BDS also updated its database to more systematically track solar energy installations.

3.3 Incentives

Program	Refund	Comment
Oregon Utility Cash Incentives	In Pacific Power territory: $0.75 per watt installed and capped at $7,500 per residence of Pacific Power	Have a solar resource (TSRF) of 75% or higher 10 years of roof life Be installed by a certified Trade Ally of Energy Trust of Oregon.

	In Portland General Electric (PGE) territory: $0.64 watt installed and capped at $6,400 for Portland General Electric per residence.	Be a grid-tied system in Pacific Power or Portland General Electric territory.
Oregon Residential Energy Tax Credits (RETC)	Currently the RETC is $1.50 per watt and is based on the nameplate rating of the panels. The maximum RETC is $6,000 per site and cannot exceed 50% of the project cost after the utility incentive. Generally, any system above 3.5 kW will have maxed out the RETC and receive the full $6,000. The RETC can only be claimed at a maximum of $1,500 per year, so the full amount can take up to 4 years to recover.	Produce 75% or greater of Total Solar Resource Fraction. Be verified by a tax credit-certified technician. Both grid-tied and off-grid solar systems are eligible to receive the RETC.
Renewable Energy Development Grant	Recipients receive up to $250,000 per project, but not more than 35 percent of eligible project costs.	Eligible recipients include Oregon businesses, organizations, public bodies, nonprofits, tribes, and residential rental properties that install and operate a renewable energy production system that produces electricity.
Small-Scale Energy Loan	The loan program is administered by The Oregon Department of Energy (ODOE)	Loans are provided to individuals, businesses, non-profit organizations, schools, and local, state, federal and tribal governments.
Property Tax Exemption for Alternative Energy Systems	The loan program is administered by The Oregon Department of Energy (ODOE)	Loans are provided to individuals, businesses, non-profit organizations, schools, and local, state, federal and tribal governments.

Table 1: Incentives

4. The Public Utility Regulatory Policies Act of 1978 (PURPA) and Pacific Power PPA

The Public Utility Regulatory Policies Act (PURPA) was passed through Congress in 1978. At the time, the US was facing an energy crisis. A dependence on foreign oil had left prices sky high along with a supply that was decreasing by the day. Public sentiment was turning to fear; a $100 barrel of gas was a real possibility. To counteract these valid concerns the public was feeling, congress enacted PURPA with several goals in mind: [8]

1. The conservation of electric energy
2. Increased efficiency in the use of facilities and resources by electric utilities
3. Equitable retail rates for electric consumers
4. Expeditious development of hydroelectric potential at existing small dams
5. Conservation of natural gas while ensuring that rates to natural gas consumers are equitable.

One of main outcomes of PURPA and the reason it is relevant to this study was that it created a new market for non-utility power producers. Traditionally, utilities had been natural monopolies as they were the only ones allowed to operate electrical power generating facilities. PURPA made it mandatory that utilities buy electricity from independent qualified facilities which fell in the right categories. The price was set at the avoided cost, or the price at which it would have cost the utility to produce that power.

Public utilities in Oregon are not exempt from this act of congress; Pacific Power highlights several generic Power Purchase Agreements (PPA) on their publicly accessible webpage [9]. Qualified facilities can sign contracts with Pacific Power at standard predetermined pricing options set at their avoided costs. Renewable fixed avoided cost pricing contracts lock in the price that Pacific

Power buys electricity from a facility at the time of the signing of the contract for 15 years. The contract states that facilities must transfer ownership of environmental attributes and green tags to the utility for the length of the contract. Due to the relative ease, generic approach and guidelines, this type of agreement would be favorable for a firm like ours. This avoided cost pricing is built into the financial analysis of our study.

5. Feasibility Simulation

5.1 Monte Carlo Analysis

In order to forecast the most realistic result to compute if the project is profitable, we performed a Monte Carlo Analysis with a simulation of implementation at different percentage of customer participation. A model grid network (Figure 5) [10] with 3638 potential customer is used as a target area (Table 2), however, to produce the most accurate simulation, ideally we would need to have complete system Information about customers such as their house capacity, need for PV generation (their average consumption and their rooftop area) as well as their wealthiness and their willingness. As we do not have enough information, we made some assumption:

- We considered residential home as participating customer
- Only 3 sizes of PVs were available to be selected (2kW, 7kW, and 12kW)
- Each customer's potential capacity is determined based on its allocated load (Table 3).

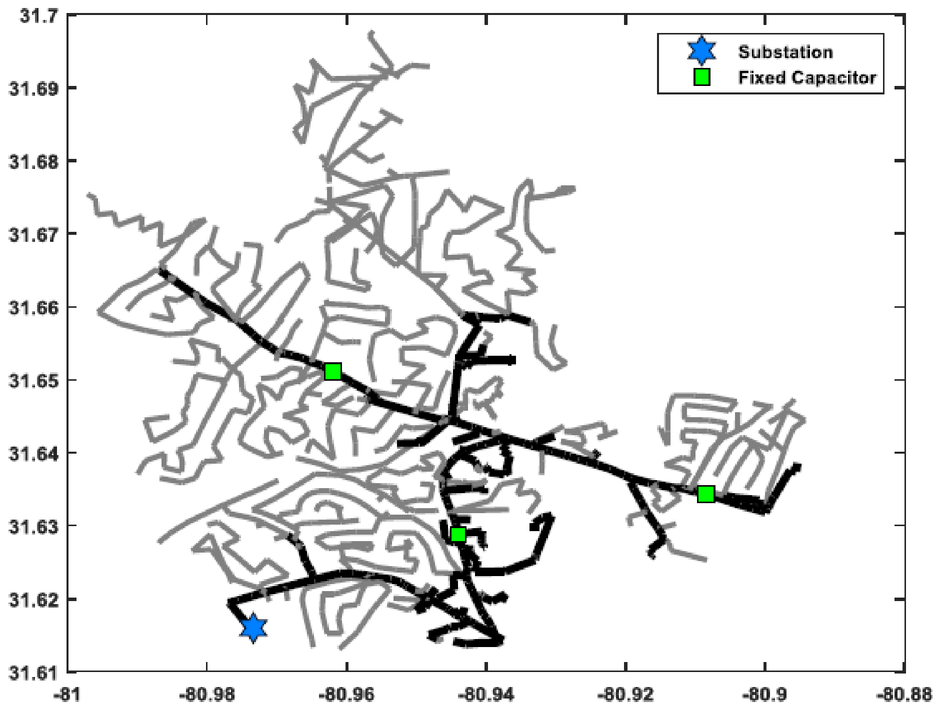

Figure 5: Model Grid Network with Coordinate used for PV Implementation Simulation

Number of Potential Customers	3638
Average maximum daily loads	17.466 MW

Table 2: Average maximum daily load

Potential PV Capacity	Number of Customers	Range of Allocated Loads
2 KW	637	p ≤ 2 KW
7 KW	2903	2KW < p < 12 KW
12 KW	98	p ≥ 12KW

Table 3: Number of customer for each PV capacity estimation

5.1.1 Monte Carlo Analysis for PV Distribution

Monte Carlo Analysis which is used frequently as an algorithm to forecast future effect of different phenomena in different areas, Monte Carlo simulation is a technique used to approximate the probability of certain outcome by performing multiple simulations using random variables. Monte Carlo takes a sample of all possible combinations, and as we increase the size of this sample population, the outcome will be more realistic.

Total number of 3638 residential customers within the model grid network is considered to be potential customer for the project. As it can be predicted, due to high number of customers a single random distribution will not shows the realistic effect of PV penetration. Ideally we have to consider all of the possible combinations, which is not possible.

As the fundamental purpose of Monte Carlo Analysis, we distribute PVs randomly at different locations and potential PV capacity within the network in order to observe the effect of PV implementation and determine the amount of power the project is able to generate with different percentage penetration. Our Monte Carlo Analysis model simulate random scenarios for 100 iterations for different level of penetrations (10%, 20%, 30%, 40% and 50%).

5.1.2 Solar Irradiation Data

In order to investigate the effect of PV variability in target area for a yearly analysis, we collect a set of real data downloaded from NREL website (available online) for Portland area in 2015 [11]. This data was processed and normalized to create the PV shape. Figure 6 shows the resulted PV profile used in this project, where data were collected hourly for one-year duration (8760 hours).

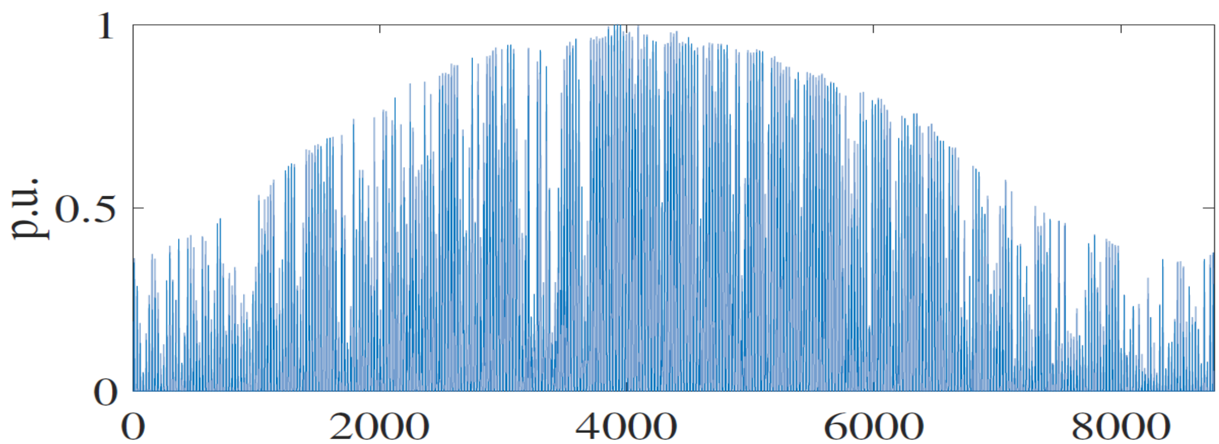

Figure 6: PV profile obtained from NREL solar tools for Portland area (2015)

5.1.3 Seasonal PV Impact on Load

From the grid model we selected, it contains a base case load profile (Figure 7) for the target area and in order to observe how PV impact on load profile for different level of penetrations in each season, 4 seasonally- representative load curves are plotted in Figure 8.

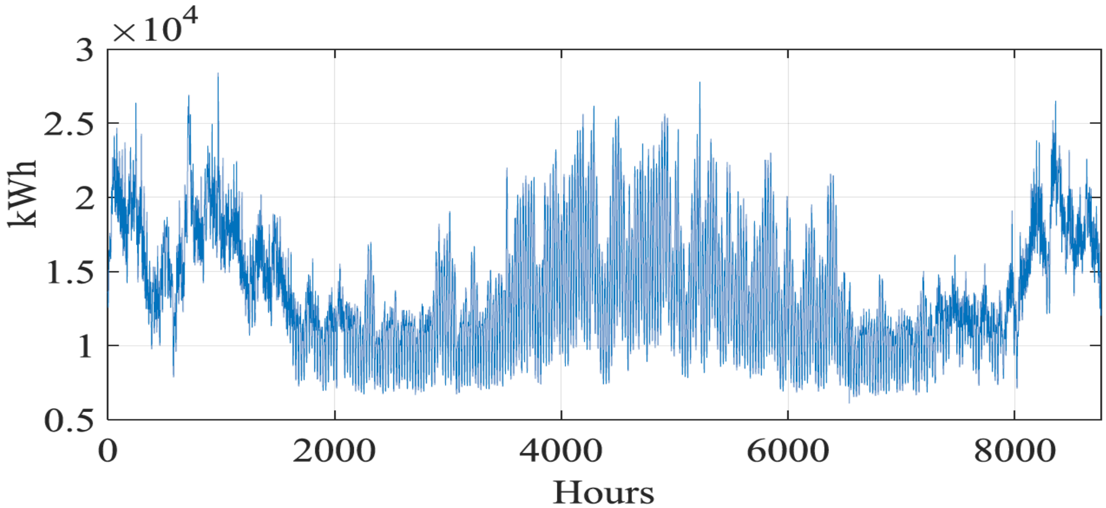

Figure 7: Gird Network Model Net Load Profile

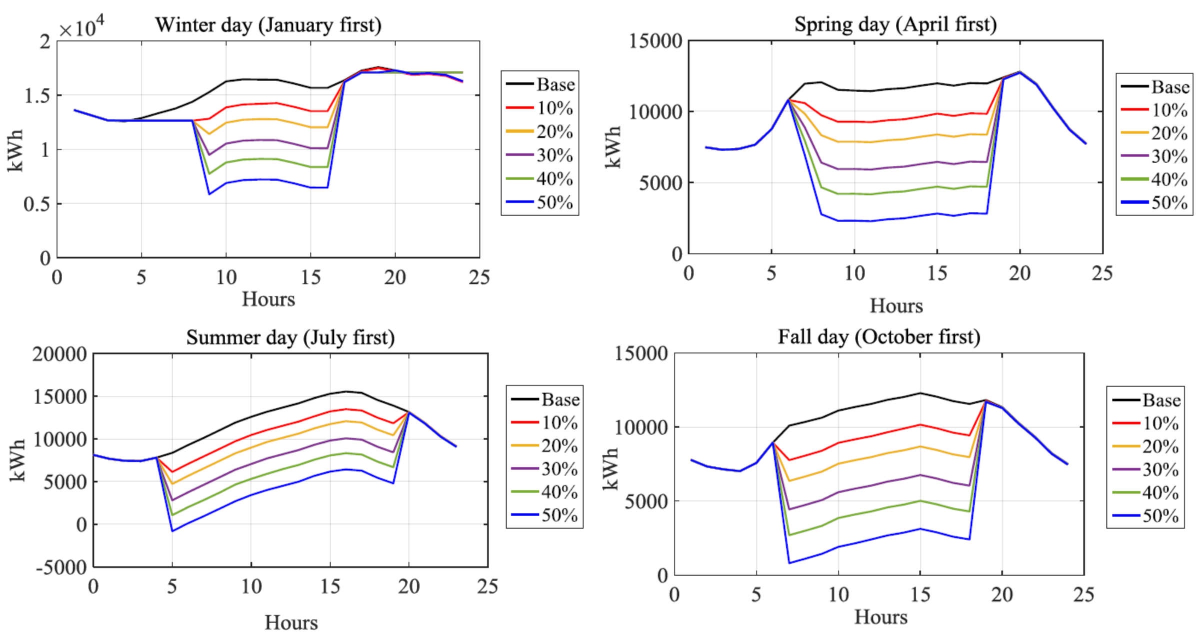

Figure 8: Seasonally representative load curves

5.1.4 Simulation Result

During the process of applying the Monte Carlo Analysis, we randomly placed PV at the grid network with different percentage of penetration. As a visual understanding, figure 10 provides an image of the grid with PV placed. Based on the 100 iterations that were considered, Figure 9 shows the distribution of the aggregated total PVs MW around the sample mean (the certain level of penetration) for 100 iterations. The average number of selected PVs from each size in 100 iterations for different level of penetrations.

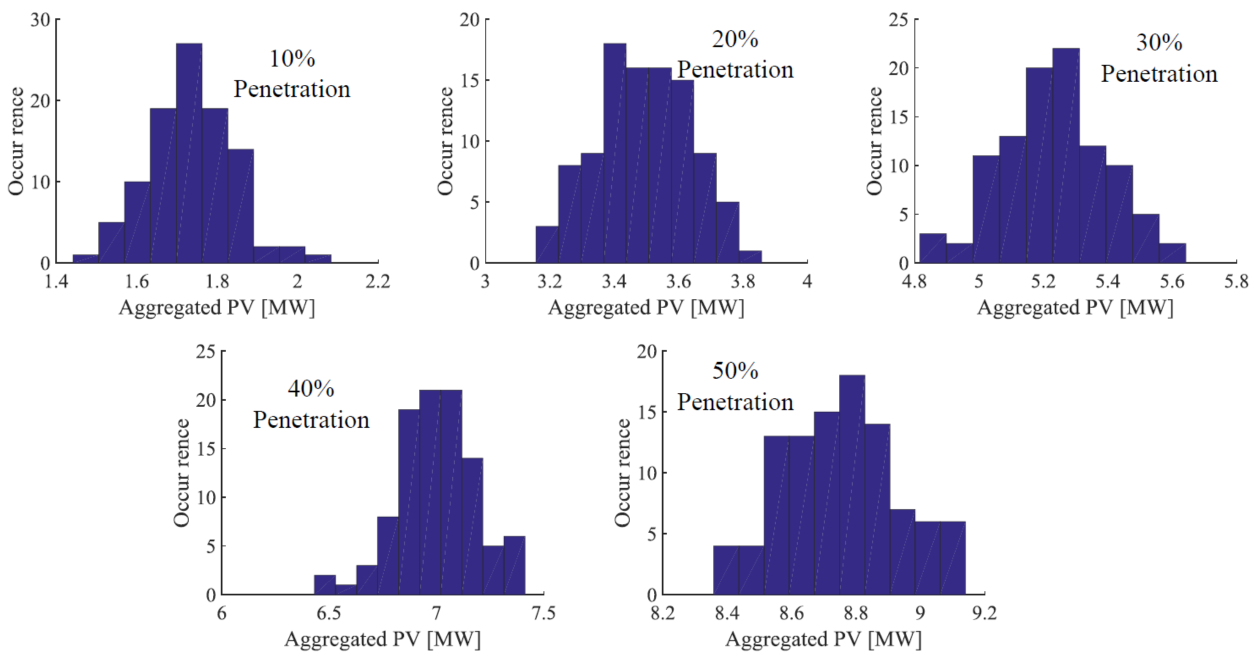

Figure 9: Distribution of aggregated PV MW in 100 iterations of the Monte Carlo

PV Size	2 KW	7 KW	12 KW
10 % PV penetrations	~ 49	~ 221	~ 8
20 % PV penetrations	~ 99	~ 445	~ 15
30 % PV penetrations	~ 145	~ 668	~ 22
40 % PV penetrations	~ 196	~ 892	~ 30
50 % PV penetrations	~244	~ 1115	~ 38

Table 4: Average number of selection of different PV sizes for different penetration level in 100 iterations

Percentage penetration	10%	20%	30%	40%	50%
Energy generated	1.7 MW	3.4 MW	5.3 MW	7.2 MW	8.8 MW

Table 5: Amount of energy that is most likely to be generated in a year at different percentage penetration

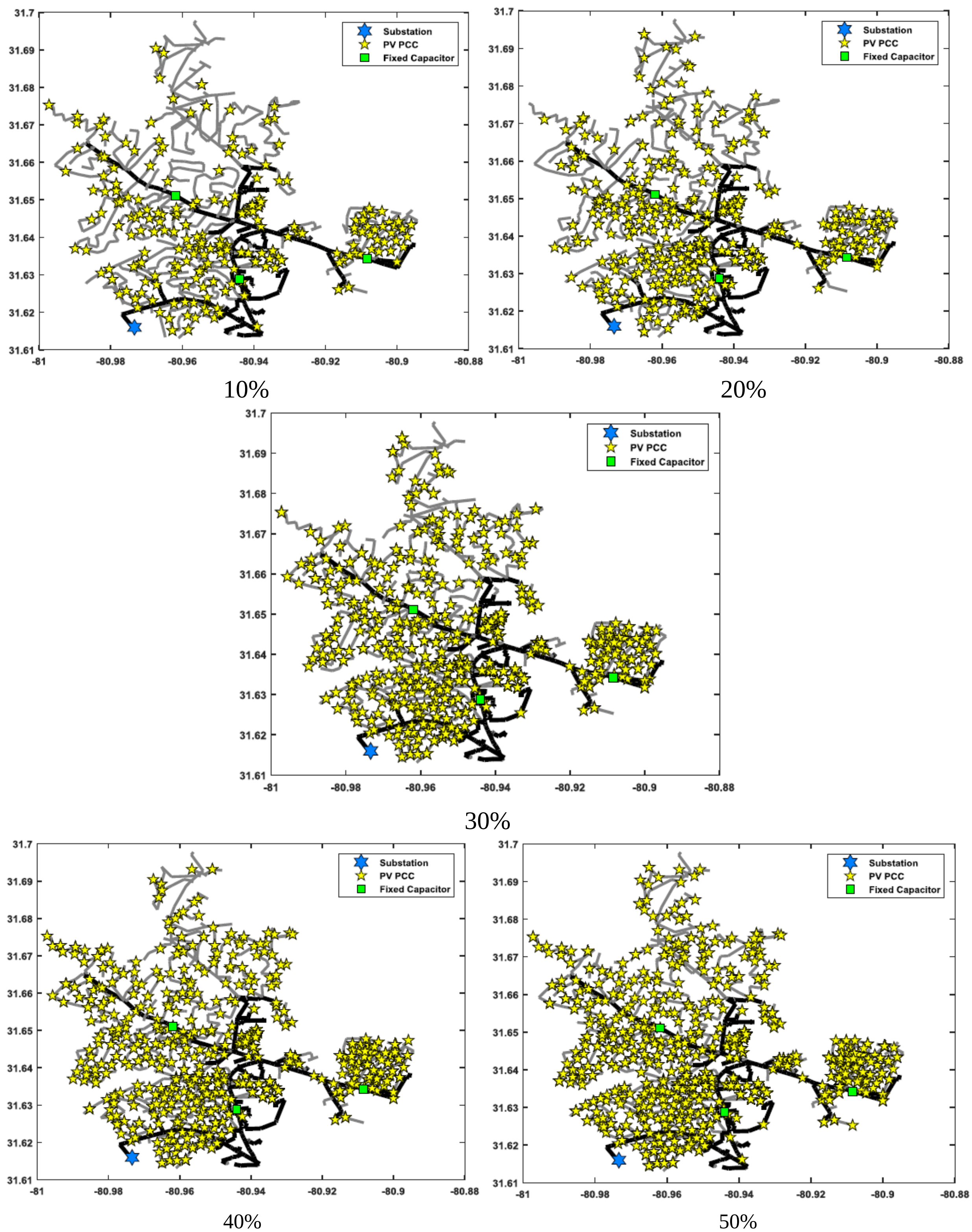

Figure 10: 10%, 20%, 30%, 40%, 50% Participations PV location on Model Grid Network

5.1.5 Analytical Discussion

According to the result obtain from the Monte Carlo Analysis, Table 5 is created to show the estimate amount of power that the simulation was able to generate with the most occasions. This only provide the scenarios of each percentage participation that occurs that most among the 100 random placement simulations.

This number is acceptably precise considering 100 iterations with realistic solar irradiation data and a lifelike model of a residential grid network. However, the result obtained in the project can be enhance by increasing the number of simulation performed and using a different solar irradiation data collected at the target area with a Global Horizontal Irradiation (GHI) data instead of a relatively ideal Direct Normal Irradiation (DNI) data.

However, in terms of an analytical simulation to obtain a possible key value for determining the feasibility of the project, the result is relatively accurate enough. The analytic result from the Monte Carlo Analysis can be used toward the following NREL financial feasibility simulation.

5.2 Financial Analysis

The financial analysis of this study uses public data and common industry tools to make assumptions about the financial feasibility of our type of business model. There are certainly some missing pieces of a traditional business operation but for the most part it encompasses a majority of line items associated with a solar development division of a firm. Its development serves as a good base to understanding if this type of business model should be further analyzed or be completely put to bed.

The analysis is rooted in the 8,760 hourly residential consumption data our team has been fortunate to gather from a community of 3,638 PGE customers. For the financial analysis, the data was manipulated into average single resident hourly energy consumption. In turn, this was added to NREL's System advisory model (SAM) along with other inputs discussed shortly. SAM is a performance and financial model tool created by NREL for developers and analysts in the renewable energy field. Using their PV Watts performance function, we created 3 models for each type of system size (2kW, 7kW, 12kW) the company will offer as a roof rental.

Eight different tabs of inputs (including the load data) were added into SAM to give us an accurate representation of the performance and financial costs of each individual system. Base weather data from Portland international airport was used as the location of the system. System costs of $3.89 per watt were discounted from costs outlined in an ETO paper written in 2014[12]. We assumed a debt of 0% for this model because it serves as a better representation of the cost of just the development department. Accounting for interest on capital expenditures would fall on the finance department of the firm and therefore, out of the scope of this analysis. Incentives include the Oregon Residential energy tax credit and the renewable energy national tax credit, both noted in an earlier section of this study. Finally, our average electric load data is uploaded into our System Advisory Model.

The SAM simulation provides us with a lot of useful data, information and graphs. Each System hourly power generation in kWh is the most significant. It is what our Cash Flow analysis is based off of. Breaking down peak production and non-peak production allows us to use the Pacific Power avoided cost prices mentioned above to calculate how much each individual system can sell its electricity to the utility for. The business plan calls for our systems to be installed on customer's roof for a flat yearly roof rental fee, paid to the customer based on system size. Rental payments are based on would be energy bill saving if the same size system were installed on their homes. Referencing our cash flow analysis in Appendices I, II, II, for an example, our 7 kWh system starts at a rental payment of $600 a year and increasing by $50 a year for 10 years until it remains constant. A regular 7kW system installed on a Portland residence would save a homeowner on average $900 a year. Our rental payments reach $900 in year seven of the systems life span making it cost even on energy bill savings for a homeowner without the added capital expenditures and risk associated with installation of their own system.

Other costs related to our system development include operation and maintenance expenses, insurance and property taxes. Relatively low O&M cost are assumed giving the small scale of each system and zero fuel inputs needed for this type of renewable energy generation. State income taxes are included along with the Oregon Residential energy tax credit. National income taxes are also assumed with national energy tax credits.

Our breakeven point for all three systems occurs in years nine, ten and eleven. Due to the increasing yearly nature of the avoided cost price structure, the cash flow increases quickly once we hit that breakeven point. Like any residential structure we start seeing quality returns once we hit that breakeven point. Looking at ways to find this point earlier, there might be a possibility to decrease our rental payments. Total capital costs assumed by the firm bring tons of risk and exposure. There might be some wiggle room but this is a question more for marketing.

6. Results

With the combination of the two analytical simulation in order to determine the feasibility to implement the business model, the result is observed to the sufficiently profitable. Figure 11 uses data from Table 4 and Cash Flow data for each PV size from Appendix I, II and III to obtain the combine Cost and Profit plot for the complete business model. Since both analyses were performed on a base with realistic circumstances and consideration of actual limitations, the obtained result is considered to be reasonably reliable. However, the simulations under this study is still relatively ideal, such as no debt were included and the business model is designed on a base that there is no financial limitation during the process of implementation. Hence, certain deviations would likely to occur during the actual execution process.

6.1 Is this new business model profitable?

To answer the question, if simply based on the result obtained from this particular feasibility study, the new business model is absolutely profitable. According to the financial analysis based on data from Monte Carlo analysis, a plot of Cost and Profit Profile for 15 years Duration is obtained (Figure 11).

The plot is showing the cost and profit for the business model at different percentage of participations with 15 years. We can observe that as the percentage of participation increase, the initial investment would increase accordingly. However, as the number of participating customers and initial investment increase, the returning profit correspondingly increase as well. And, the potential profit is shown to be continuously increasing with the number of years increasing. Therefore, as a result, it shows that the business model is implementable, and the company will be able to gain significant amount of profit as if the project continues for a long period of time.

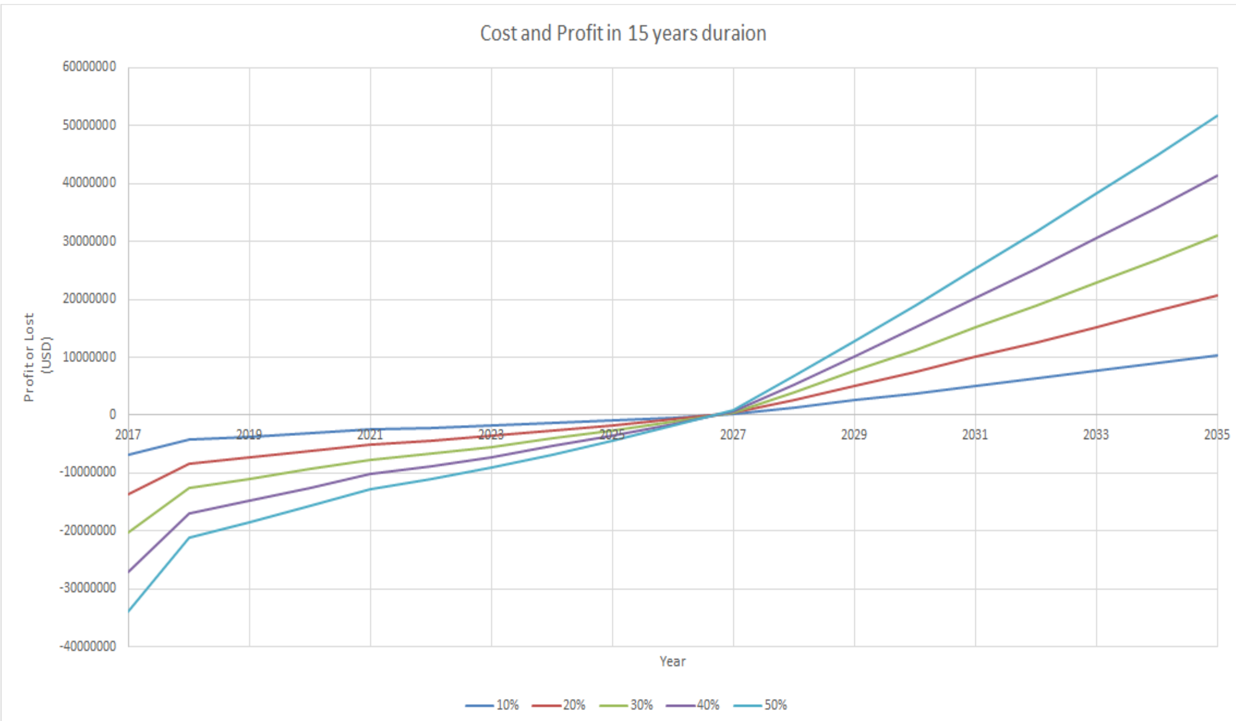

Figure 11: Complete Business Model Profit and Loss Diagram

6.2 How long is the return period for the new business model to be profitable?

With simple observation from Figure 11 and according to the cash flow of the complete project (Appendix IV) and each PV sizes (Appendix I, II, III), the return period is determined to be approximately around 10 years. Considering this business model being a part of the energy industry, the return period is considered to be relatively short and acceptable. Furthermore, with the consideration of the duration of Pacific Power's Power Purchase Agreement (PPA), which is 15 years, the business model would still be able to breakeven and even obtain a sufficient amount of profit with the limited amount of time.

7. Conclusion

Extensive Research on market analysis, policies and incentives, feasibility simulation which contains Monte Carlo analysis for PV distribution and financial analysis. The market analysis reveal that there is a definite need for solar and the market is growing each year with policies and incentives provided by the state and federal government. After financial analysis it is clear that this business model is profitable and the break-even point to get this business profitable is nine years for 2kW and 7 kW PV and ten years for 12kW PV. The result can be seen in the Figure 11, the highest the penetration, i.e. 50% penetration, means more investment and a higher potential in the obtainable profit after break-even point.

This study is more inclined to be a material that provides a better understanding on current renewable energy market and a brief description on certain methodologies can be used to further determine the feasibility of such project.

In conclusion, this residential PV implementation project, based on current researches and analytical feasibility simulation, the business model is unquestionably profitable with an astounding future potential and a reasonable return period. As a result, this project can be taken onto further consideration within the company and optimistically assist the company to gain a satisfactory amount of profit in the future.

References

[1] "6 Tempting Reasons to Install Solar Panels." Solar Power Authority. N.p., 29 Nov. 2016. Web. 13 June 2017. https://www.solarpowerauthority.com/most-appealing-reasons-to-install-solar-panels/
[2] Wednesday, March 9 2016. "US Solar Market Set to Grow 119% in 2016, Installations to Reach 16 GW." SEIA. N.p., 09 Mar. 2016. Web. 13 June 2017. http://www.seia.org/news/us-solar-market-set-grow-119-2016-installations-reach-16-gw
[3] "U.S. Solar Market Insight 2013 Q1." SEIA. N.p., n.d. Web. 13 June 2017. http://www.seia.org/research-resources/us-solar-market-insight-2013-q1
[4] "Portland Ranks 17 for Total Solar PV Installed." Portland Ranks 17 for Total Solar PV Installed | Environment Oregon. N.p., 04 Apr. 2017. Web. 13 June 2017. http://environmentoregon.org/news/ore/portland-ranks-17-total-solar-pv-installed
[5] "Oregon Solar Installer." N.p., n.d. Web. http://www.cleanenergyauthority.com/oregon-solar-installers/
[6] "NREL Report Shows U.S. Solar Photovoltaic Costs Continuing to Fall in 2016." NREL Report Shows U.S. Solar Photovoltaic Costs Continuing to Fall in 2016 - News Releases | NREL. N.p., n.d. Web. 13 June 2017. http://www.nrel.gov/news/press/2016/37745
[7] "Code Guides." Commercial Building Code Guides. The City of Portland OREGON, n.d. Web. www.portlandonline.com/bds/index.cfm?c=36855
[8] "What Is a Qualifying Facility?" FERC: Qualifying Facilities. FERC, 18 Nov. 2016. Web. 13 June 2017. https://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp
[9]"Qualifying Facility." Pacific Power, Web. June 12, 2017.
https://www.pacificpower.net/env/nmcg/qf.html

[10] "OpenDSS - Circuit 24 Grid Model." EPRI | Smart Grid Resource Center Simulation Tool – OpenDSS. EPRI - OpenDSS, n.d. Web. 13 June 2017.
[11] "Solar Tools for Portland Area (2015)." National Renewable Energy Laboratory (NREL) Home Page. NREL, n.d. Web. 13 June 2017.
[12] Jeni Hall (2015, Sep) "Benchmarking Oregon Solar Soft Costs 2014 Installer Survey Analysis"
http://assets.energytrust.org/api/assets/reports/Benchmarking_Solar_Soft_Costs_2014.pdf [Jun. 1, 2017]
[13] Solar America Board for Codes and Standards, "Impacts on Photovoltaic Installations of Changes to the 2012 International Codes," May 2011, www.solarabcs.org/about/
publications/reports/2012Codes/pdfs/ABCS-22whitepaper.pdf.
[14] Oregon Department of Consumer and Business Services, "Oregon Solar Installation Specialty Code," October 2010, http://oregonhba.com.s163554.gridserver.com/wp-content/ uploads/2014/12/Oregon-Solar-installation-code.pdf.
[15] Northwest Solar Communities, "Solar: Simple, Fast, and Cost Effective,"
http://nwsolarcommunities.org/wp-content/ uploads/2015/09/NSC-OR-Permit-Pkg-B_04162015.pdf.
[16] Oregon Department of Consumer and Business Services, "Oregon Solar Installation Specialty Code: Checklist for Prescriptive Photovoltaic Installations in accordance with Section 3111.5.3," https://www.oregon.gov/bcd/ Forms library/4910.pdf.
[17] 2015 IRC, Appendix U,
http://codes.iccsafe.org/app/book/content/2015%20San%20Antonio/2015%20IRC%20
HTML/Appendix%20U.html.
[18] The south-facing side of a building gets the most sunlight, making it "prime real estate" for a locating a PV system…

Appendix I – 2kW Cash Flow

	Year																		
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Initial outlay	$7,780.00																		
PRODUCTION																			
Energy (kWh)	0	2,271	2,260	2,249	2,238	2,226	2,215	2,204	2,193	2,182	2,171	2,160	2,150	2,139	2,128	2,118	2,107	2,096	2,086
Peak Energy Production (kWh) (6AM-10PM)	99.763%	2,266	2,255	2,244	2,233	2,221	2,210	2,199	2,188	2,177	2,166	2,155	2,145	2,134	2,123	2,113	2,102	2,091	2,081
Non-Peak Energy Production	0.239%	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Revenue																			
On Peak Prices	0.263	0.282	0.294	0.31	0.33	0.36	0.403	0.444	0.466	0.484	0.506	0.855	0.872	0.893	0.911	0.93	0.949	0.97	0.987
Of fPeak Prices	0.217	0.23	0.238	0.251	0.271	0.3	0.337	0.373	0.393	0.409	0.427	0.66	0.674	0.687	0.703	0.72	0.737	0.755	0.776
Revenue from Peak	0	639	663	696	737	799	891	976	1,020	1,054	1,096	1,842	1,870	1,906	1,934	1,965	1,995	2,028	2,054
Revenue from non peak	0	1	1	1	1	2	2	2	2	2	2	3	3	4	4	4	4	4	4
Total Revenue	-	640	664	697	738	801	892	978	1,022	1,056	1,098	1,846	1,874	1,909	1,938	1,969	1,999	2,032	2,058
Residential Cost																			
Rental Roof Cost		- 150	- 200	- 250	- 300	- 350	- 400	- 450	- 500	- 550	- 600	- 600	- 600	- 600	- 600	- 600	- 600	- 600	- 600
OPERATING EXPENSES																			
O&M capacity-based expense ($)	0	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
Property tax expense ($)	0	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156
Insurance expense ($)	0	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39	-39
Total operating expense ($)	0	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235	-235
Deductible expenses ($)	0	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156
PROJECT DEBT																			
Debt balance ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE INCOME TAX																			
State taxable income less deductions ($)	0	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156
Total deductions	0	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156
Income tax	0	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
State ITC ($)	0	973	973	973	973	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State tax savings ($)	0	983	983	983	983	11	11	11	11	11	11	11	11	11	11	11	11	11	11
FEDERAL INCOME TAX																			
Federal taxable income less deductions ($)	0	-828	-828	-828	-828	145	145	145	145	145	145	145	145	145	145	145	145	145	145
Income Taxes	0	232	232	232	232	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41
Federal ITC ($)	0	$2,334.0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Federal tax savings ($)	0	2,102	- 232	- 232	- 232	41	41	41	41	41	41	41	41	41	41	41	41	41	41
Totals																			
PPA Sales		640	664	697	738	801	892	978	1,022	1,056	1,098	1,846	1,874	1,909	1,938	1,969	1,999	2,032	2,058
After Tax Cash Flow		2,701.11	317.11	267.11	217.11	- 533.09	- 583.09	- 633.09	- 683.09	- 733.09	- 783.09	- 783.09	- 783.09	- 783.09	- 783.09	- 783.09	- 783.09	- 783.09	- 783.09
	- 7,780.00	3,341.27	981.26	964.00	955.35	267.97	309.23	345.14	338.49	322.63	315.05	1,062.75	1,090.74	1,126.03	1,154.51	1,185.64	1,215.43	1,249.00	1,274.79
Net cash flow	$7,780.00	$4,438.73	$3,457.47	$2,493.47	$1,538.12	$1,270.15	$960.92	$615.78	$277.29	$45.34	$360.39	$1,423.14	$2,513.88	$3,639.91	$4,794.42	$5,980.06	$7,195.49	$8,444.49	$9,719.28

Appendix II – 7kW Cash Flow

	Year															
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial outlay	$27,230.00															
PRODUCTION																
Energy (kWh)	0	7,950	7,910	7,871	7,832	7,792	7,753	7,715	7,676	7,638	7,600	7,562	7,524	7,486	7,449	7,411
Peak Energy Production (kWh) (6AM-10PM)	99.763%	7,931	7,891	7,852	7,813	7,774	7,735	7,697	7,658	7,620	7,582	7,544	7,506	7,468	7,431	7,393
Non-Peak Energy Production	0.239%	19	19	19	19	19	19	18	18	18	18	18	18	18	18	18
Revenue																
On Peak Prices	0.263	0.282	0.294	0.31	0.33	0.36	0.403	0.444	0.466	0.484	0.506	0.855	0.872	0.893	0.911	0.93
Of fPeak Prices	0.217	0.23	0.238	0.251	0.271	0.3	0.337	0.373	0.393	0.409	0.427	0.66	0.674	0.687	0.703	0.72
Revenue from Peak	0	2,237	2,320	2,434	2,578	2,798	3,117	3,417	3,569	3,688	3,837	6,450	6,545	6,669	6,770	6,876
Revenue from non peak	0	4	4	5	5	6	6	7	7	7	8	12	12	12	13	13
Total Revenue	-	2,241	2,325	2,439	2,584	2,804	3,123	3,424	3,576	3,696	3,844	6,462	6,558	6,681	6,783	6,889
Residential Cost																
Rental Roof Cost		- 600	- 650	- 700	- 750	- 800	- 850	- 900	- 950	- 1,000	- 1,050	- 1,050	- 1,050	- 1,050	- 1,050	- 1,050
OPERATING EXPENSES																
O&M capacity-based expense ($)	0	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140
Property tax expense ($)	0	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545
Insurance expense ($)	0	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136	-136
Total operating expense ($)	0	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821	-821
Deductible expenses ($)	0	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545
PROJECT DEBT																
Debt balance ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE INCOME TAX																
State taxable income less deductions ($)	0	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545	-545
Income tax	0	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38
State ITC ($)	0	1,500	1,500	1,500	1,500	-	-	-	-	-	-	-	-	-	-	-
State tax savings ($)	0	1,538	1,538	1,538	1,538	38	38	38	38	38	38	38	38	38	38	38
FEDERAL INCOME TAX																
Federal taxable income less deductions ($)	0	-994	-994	-994	-994	506	506	506	506	506	506	506	506	506	506	506
Income Taxes	0	278	278	278	278	-142	-142	-142	-142	-142	-142	-142	-142	-142	-142	-142
Federal ITC ($)	0	$8,169.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Federal tax savings ($)	0	7,891	- 278	- 278	- 278	142	142	142	142	142	142	142	142	142	142	142
Totals																
PPA Sales		2,241	2,325	2,439	2,584	2,804	3,123	3,424	3,576	3,696	3,844	6,462	6,558	6,681	6,783	6,889
After Tax Cash Flow		8,008.19	- 210.81	- 260.81	- 310.81	- 1,440.81	- 1,490.81	- 1,540.81	- 1,590.81	- 1,640.81	- 1,690.81	- 1,690.81	- 1,690.81	- 1,690.81	- 1,690.81	- 1,690.81
Net cash flow	$27,230.00	$16,980.85	$14,867.12	$12,688.98	$10,416.27	$9,053.02	$7,420.52	$5,537.10	$3,552.15	$1,497.45	$656.00	$5,427.33	$10,294.04	$15,284.70	$20,376.39	$25,574.25

Appendix III – 12kW Cash Flow

System Size	12	kW														
	Year															
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial outlay	$46,680.00															
PRODUCTION																
Energy (kWh)	0	13,629	13,561	13,493	13,425	13,358	13,292	13,225	13,159	13,093	13,028	12,963	12,898	12,833	12,769	12,705
Peak Energy Production (kWh) (6AM-10PM)	99.763%	13,597	13,529	13,461	13,393	13,326	13,261	13,194	13,128	13,062	12,997	12,932	12,867	12,803	12,739	12,675
Non-Peak Energy Production	0.239%	33	32	32	32	32	32	32	31	31	31	31	31	31	31	30
Revenue																
On Peak Prices	0.263	0.282	0.294	0.31	0.33	0.36	0.403	0.444	0.466	0.484	0.506	0.855	0.872	0.893	0.911	0.93
Of fPeak Prices	0.217	0.23	0.238	0.251	0.271	0.3	0.337	0.373	0.393	0.409	0.427	0.66	0.674	0.687	0.703	0.72
Revenue from Peak	0	3,834	3,978	4,173	4,420	4,798	5,344	5,858	6,118	6,322	6,577	11,057	11,220	11,433	11,605	11,788
Revenue from non peak	0	7	8	8	9	10	11	12	12	13	13	20	21	21	21	22
Total Revenue	-	3,842	3,985	4,181	4,428	4,807	5,355	5,870	6,130	6,335	6,590	11,078	11,241	11,454	11,626	11,810
Residential Cost																
Rental Roof Cost		- 1,000	- 1,050	- 1,100	- 1,150	- 1,200	- 1,250	- 1,300	- 1,350	- 1,400	- 1,450	- 1,450	- 1,450	- 1,450	- 1,450	- 1,450
OPERATING EXPENSES																
O&M capacity-based expense ($)	0	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240	-240
Property tax expense ($)	0	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934
Insurance expense ($)	0	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233	-233
Total operating expense ($)	0	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407	-1407
Deductible expenses ($)	0	934	934	934	934	934	934	934	934	934	934	934	934	934	934	934
PROJECT DEBT																
Debt balance ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE INCOME TAX																
State taxable income less deductions ($)	0	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934	-934
Income tax	0	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65
State ITC ($)	0	1,500	1,500	1,500	1,500	-	-	-	-	-	-	-	-	-	-	-
State tax savings ($)	0	1,565	1,565	1,565	1,565	65	65	65	65	65	65	65	65	65	65	65
FEDERAL INCOME TAX																
Federal taxable income less deductions ($)	0	-632	-632	-632	-632	868	868	868	868	868	868	868	868	868	868	868
Income Taxes	0	177	177	177	177	-243	-243	-243	-243	-243	-243	-243	-243	-243	-243	-243
Federal ITC ($)	0	$14,004.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Federal tax savings ($)	0	13,827	- 177	- 177	- 177	243	243	243	243	243	243	243	243	243	243	243
Totals																
PPA Sales		3,842	3,985	4,181	4,428	4,807	5,355	5,870	6,130	6,335	6,590	11,078	11,241	11,454	11,626	11,810
After Tax Cash Flow		12,985.46	- 1,068.54	- 1,118.54	- 1,168.54	- 2,298.54	- 2,348.54	- 2,398.54	- 2,448.54	- 2,498.54	- 2,548.54	- 2,548.54	- 2,548.54	- 2,548.54	- 2,548.54	- 2,548.54
Net cash flow	$46,680.00	$29,852.76	$26,936.08	$23,873.59	$20,613.66	$18,105.12	$15,098.95	$11,627.69	$7,946.28	$4,110.00	$68.67	$8,460.39	$17,153.08	$26,058.37	$35,136.33	$44,397.35

Appendix IV – Complete Business Model Cash Flow

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
	0	1	2	3	4	5	6	7	8	9
2kW	**$7,780.00**	**$4,438.73**	**$3,457.47**	**$2,493.47**	**$1,538.12**	**$1,270.15**	**$960.92**	**$615.78**	**$277.29**	**$45.34**
7kW	**$27,230.00**	**$16,980.85**	**$14,867.12**	**$12,688.98**	**$10,416.27**	**$9,053.02**	**$7,420.52**	**$5,537.10**	**$3,552.15**	**$1,497.45**
12kW	$46,680.00	$29,852.76	$26,936.08	$23,873.59	$20,613.66	$18,105.12	$15,098.95	$11,627.69	$7,946.28	$4,110.00
2kW	$381,220.00	$217,497.98	$169,416.05	$122,180.04	$75,367.75	$62,237.19	$47,085.04	$30,173.36	$13,587.32	$2,221.69
7kW	$6,017,830.00	$3,752,767.26	$3,285,634.25	$2,804,264.07	$2,301,996.34	$2,000,716.52	$1,639,934.39	$1,223,698.47	$785,024.49	$330,935.97
12kW	$373,440.00	$238,822.08	$215,488.66	$190,988.73	$164,909.32	$144,840.97	$120,791.59	$93,021.51	$63,570.23	$32,879.98
All Systems	$6,772,490.00	$4,209,087.33	$3,670,538.96	$3,117,432.84	$2,542,273.41	$2,207,794.68	$1,807,811.02	$1,346,893.34	$862,182.04	$361,594.26
2kW	$770,220.00	$439,434.70	$342,289.56	$246,853.55	$152,273.63	$125,744.53	$95,130.99	$60,962.51	$27,451.94	$4,488.72
7kW	$12,117,350.00	$7,556,477.07	$6,615,869.87	$5,646,595.07	$4,635,241.49	$4,028,592.09	$3,302,130.34	$2,464,008.23	$1,580,705.42	$666,364.29
12kW	$700,200.00	$447,791.41	$404,041.24	$358,103.87	$309,204.97	$271,576.82	$226,484.24	$174,415.32	$119,194.18	$61,649.96
All Systems	$13,587,770.00	$8,443,703.18	$7,362,200.67	$6,251,552.49	$5,096,720.09	$4,425,913.44	$3,623,745.57	$2,699,386.06	$1,727,351.54	$723,525.53
2kW	$1,128,100.00	$643,616.48	$501,333.20	$361,553.17	$223,027.03	$184,171.29	$139,333.27	$89,288.53	$40,207.39	$6,574.39
7kW	$18,189,640.00	$11,343,206.03	$9,931,238.37	$8,476,237.09	$6,958,070.38	$6,047,414.64	$4,956,905.77	$3,698,780.89	$2,372,834.21	$1,000,295.16
12kW	$1,026,960.00	$656,760.73	$592,593.81	$525,219.01	$453,500.62	$398,312.66	$332,176.88	$255,809.14	$174,818.13	$90,419.94
All Systems	$20,344,700.00	$12,643,583.24	$11,025,165.38	$9,363,009.28	$7,634,598.03	$6,629,898.59	$5,428,415.92	$4,043,878.56	$2,587,859.72	$1,084,140.71
2kW	$1,524,880.00	$869,991.93	$677,664.18	$488,720.15	$301,471.02	$248,948.77	$188,340.15	$120,693.46	$54,349.29	$8,886.77
7kW	$24,289,160.00	$15,146,915.84	$13,261,473.99	$11,318,568.10	$9,291,315.53	$8,075,290.21	$6,619,101.71	$4,939,090.65	$3,168,515.14	$1,335,723.48
12kW	$1,400,400.00	$895,582.81	$808,082.47	$716,207.74	$618,409.94	$543,153.63	$452,968.48	$348,830.65	$238,388.36	$123,299.91
All Systems	$27,214,440.00	$16,912,490.58	$14,747,220.65	$12,523,495.99	$10,211,196.49	$8,867,392.62	$7,260,410.34	$5,408,614.75	$3,461,252.79	$1,450,136.63
2kW	$1,898,320.00	$1,083,051.18	$843,622.76	$608,406.72	$375,300.66	$309,915.82	$234,464.27	$150,251.04	$67,659.32	$11,063.12
7kW	$30,361,450.00	$18,933,644.80	$16,576,842.49	$14,148,210.12	$11,614,144.42	$10,094,112.76	$8,273,877.14	$6,173,863.31	$3,960,643.92	$1,669,654.35
12kW	$1,773,840.00	$1,134,404.89	$1,023,571.13	$907,196.47	$783,319.25	$687,994.60	$573,760.07	$441,852.16	$301,958.59	$156,179.89
All Systems	$34,033,610.00	$21,151,100.87	$18,444,036.38	$15,663,813.31	$12,772,764.33	$11,092,023.19	$9,082,101.48	$6,765,966.50	$4,330,261.84	$1,814,771.12

	2027	2028	2029	2030	2031	2032	2033	2034	2035
	10	11	12	13	14	15	16	17	18
2kW	**$360.39**	**$1,423.14**	**$2,513.88**	**$3,639.91**	**$4,794.42**	**$5,980.06**	**$7,195.49**	**$8,444.49**	**$9,719.28**
7kW	**$656.00**	**$5,427.33**	**$10,294.04**	**$15,284.70**	**$20,376.39**	**$25,574.25**	**$30,877.80**	**$36,300.28**	**$41,812.05**
12kW	$68.67	$8,460.39	$17,153.08	$26,058.37	$35,136.33	$44,397.35	$53,839.96	$63,486.89	$73,285.63
2kW	$17,659.30	$69,733.99	$123,180.18	$178,355.69	$234,926.57	$293,022.70	$352,579.00	$413,780.14	$476,244.88
7kW	$144,975.36	$1,199,439.21	$2,274,982.95	$3,377,919.17	$4,503,182.15	$5,651,910.26	$6,823,994.08	$8,022,362.10	$9,240,462.65
12kW	$549.33	$67,683.12	$137,224.63	$208,466.97	$281,090.62	$355,178.81	$430,719.67	$507,895.08	$586,285.03
All Systems	$162,085.33	$1,336,856.32	$2,535,387.76	$3,764,741.83	$5,019,199.35	$6,300,111.78	$7,607,292.75	$8,944,037.32	$10,302,992.57
2kW	$35,678.99	$140,891.11	$248,874.24	$360,351.29	$474,647.56	$592,025.46	$712,353.48	$836,004.77	$962,209.05
7kW	$291,918.72	$2,415,160.41	$4,580,848.02	$6,801,692.44	$9,067,493.47	$11,380,543.29	$13,740,621.56	$16,153,625.04	$18,606,361.45
12kW	$1,029.99	$126,905.85	$257,296.18	$390,875.56	$527,044.92	$665,960.28	$807,599.39	$952,303.28	$1,099,284.43
All Systems	$326,567.72	$2,682,957.37	$5,087,018.44	$7,552,919.30	$10,069,185.95	$12,638,529.03	$15,260,574.43	$17,941,933.09	$20,667,854.93
2kW	$52,257.11	$206,355.67	$364,512.78	$527,787.25	$695,190.87	$867,108.00	$1,043,346.01	$1,224,451.44	$1,409,296.08
7kW	$438,206.08	$3,625,454.28	$6,876,419.05	$10,210,181.01	$13,611,428.40	$17,083,602.06	$20,626,371.24	$24,248,587.70	$27,930,448.20
12kW	$1,510.66	$186,128.57	$377,367.73	$573,284.16	$772,999.22	$976,741.74	$1,184,479.10	$1,396,711.47	$1,612,283.84
All Systems	$488,952.53	$4,017,938.52	$7,618,299.56	$11,311,252.42	$15,079,618.49	$18,927,451.80	$22,854,196.36	$26,869,750.61	$30,952,028.12
2kW	$70,637.19	$278,935.94	$492,720.72	$713,422.76	$939,706.28	$1,172,090.82	$1,410,315.99	$1,655,120.56	$1,904,979.53
7kW	$585,149.43	$4,841,175.47	$9,182,284.12	$13,633,954.29	$18,175,739.72	$22,812,235.09	$27,542,998.72	$32,379,850.64	$37,296,347.00
12kW	$2,059.99	$253,811.69	$514,592.36	$781,751.13	$1,054,089.84	$1,331,920.55	$1,615,198.77	$1,904,606.55	$2,198,568.87
All Systems	$653,726.64	$5,373,923.11	$10,189,597.20	$15,129,128.18	$20,169,535.84	$25,316,246.46	$30,568,513.49	$35,939,577.76	$41,399,895.40
2kW	$87,936.10	$347,246.79	$613,387.02	$888,138.54	$1,169,838.43	$1,459,133.47	$1,755,699.50	$2,060,456.21	$2,371,505.12
7kW	$731,436.79	$6,051,469.34	$11,477,855.16	$17,042,442.86	$22,719,674.65	$28,515,293.86	$34,428,748.41	$40,474,813.30	$46,620,433.75
12kW	$2,609.32	$321,494.81	$651,816.99	$990,218.10	$1,335,180.47	$1,687,099.37	$2,045,918.45	$2,412,501.64	$2,784,853.90
All Systems	$816,763.57	$6,720,210.94	$12,743,059.16	$18,920,799.50	$25,224,693.55	$31,661,526.69	$38,230,366.35	$44,947,771.15	$51,776,792.78