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Cost Analysis for Renewable Energy at Residential Houses in CA

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Cost Analysis for Renewable Energy at Residential Houses in CA

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1. Abstract

Solar energy has been demonstrated to be the most productive and compelling among sustainable power hotspots for home and business use. California has made a concerted effort to boost the integration of renewables into the grid. In 2020, a "solar mandate" went into effect, and in 2022, the California Energy Commission released the draft language for the 2022 building standards. The use of photovoltaic (PV) systems supports the achievement of Sustainable Development Goals (SDGs) – particularly SDG 13 in direct impact – through preserving the environment, reducing the levels of greenhouse gasses (GHGs), and accordingly reducing global warming. Therefore, the PV solar system is considered a resilient energy economy, however, there is still debate around its profitability for customers. This study aims to analyze the economic impact on homeowners in CA when they use solar panels compared to traditional power bills. To conclude with recommendations, the team has performed cost analysis to determine the profitability of solar power from the homeowner's perspective. The results of calculations – including incremental analysis, cost benefit or break-even analysis – solar system as source of electricity for homeowners proves to be a valuable investment on a mid to long term basis.

2. Introduction

In 2018 the California Energy Commission adopted building standards that require solar photovoltaic systems in 2020 [1]. The 2019 Building Energy Efficiency Standards (Energy Code) has solar photovoltaic (PV) system requirements for all newly constructed low-rise residential buildings [2]. The stakeholders of the mandate include local government, electricity service providers, private suppliers of solar energy, homeowners and energy technology industry. Our research focuses on the perspective of homeowners. The solar mandate will not impact existing residential houses. Homeowners of houses built before 2020 can keep their existing power supply option or install solar power. They can take advantage of the incentive programs that are provided for solar power installations. Our study performs cost effectiveness analysis and compares the solar power option against the baseline grid power. There are other factors to assess such as cost implications of energy efficiency and renewable strategies. The goal of our project is to identify the efficient and sustainable energy source for homeowners in Southern California that reduces the cost of energy for them.

3. Background

California is considered as one of the promising states in the country for generating solar energy due to different factors such as pro-solar policies, sunlight hours throughout the year, and attractive solar incentives. According to the California Energy Commission 2019, Title 24 has been "designed to reduce wasteful and unnecessary energy consumption in newly constructed and existing buildings." One of the main policies of Title 24 is the "California's Building Standard Codes", which includes article 6 of "Building Energy Efficiency Standards" which states that solar photovoltaic (PV) system is mandatory for all newly built houses that are three floors and below and have permit applications on January 1, 2020, or after. The system should be licensed according to the space of house and climate zone in the area, with exceptions to only too small or mostly shaded houses. According to the standards code, the minimum size of the residential PV system ranges from 2.7kw to 5.7kw. Some parties consider Building Energy Efficiency Standards a promising solution to save billions of dollars at California level from electricity bills and to achieve the blueprint of reducing wasteful and unnecessary energy consumption. On the other hand, some have concerns about the increase of upfront cost of houses for single families, with an estimated increase of $,8400 in total cost, that may make the housing issue in california worse, while clean energy advocates confirm that this increase will be returned from the saving of electricity bills saving along years.

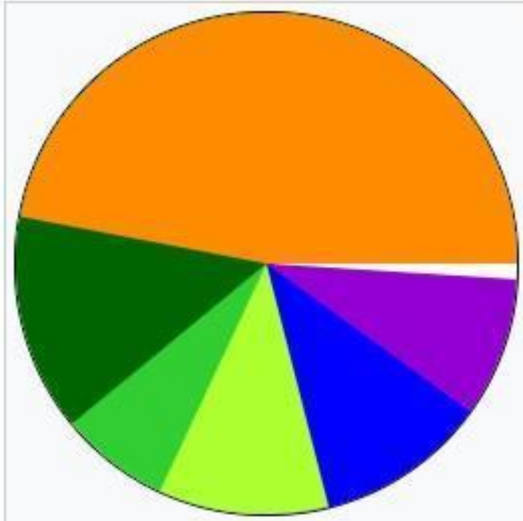
As of 2018, California had 80 GW of installed generation capacity encompassing more than 1,500 power plants: with 41 GW of natural gas, 26.5 GW of renewable (12 GW solar, 6 GW wind), 12 GW large hydroelectric, and 2.4 GW nuclear.

Legal renewables requirement:

In 2006, the California legislature passed the Global Warming Solutions Act of 2006 which set a goal for 33% of electricity consumption in California to be generated by renewable sources by 2020. In 2015, SB350 mandated that electric utilities purchase 50% of their electricity from renewable sources by 2030. Then in 2018, Senate Bill 100 was passed which increased the renewables requirement for electric utilities to 50% by 2026, 60% by 2030, and 100% by 2045.

[3]. Solar power in California includes utility-scale solar power plants as well as local distributed generation, mostly from rooftop photovoltaics. It has been growing rapidly because of high insolation, community support, declining solar costs, and a Renewable Portfolio Standard which requires that

33% of California's electricity will come from renewable resources by 2020, and 60% by 2030. Much of this is expected to come from solar power via photovoltaic facilities or concentrated solar power facilities. [4]



Sources of California in-state electricity generation: 2018[1] This accounted for 68% of CA's demand in 2018; the remaining 32% was imported.[1]

Natural gas (47%)
Renewables - Solar (14%)
Renewables - Wind (7%)
Renewables - Other (Geothermal, biomass, etc.) (11%)
Large hydro (11%)
Nuclear (9%)

Figure on the right shows the electricity generation percentage in California as per demand. This is how we have studied the factors for deciding the best possible solution for the homeowners.

For homeowners, possible solutions from the available resources of power generation are Solar energy standalone units and regular grid supply sources which are under California state billing cycle regulations. Rest solutions are not feasible to be considered under study due to the capacity and requirement of the homeowners' community. We will be calculating the structure and characteristics of each source and will end up calculating the economical formulation for each source to be compared further in the study.

The solar mandate being new, there is room for new literature that compares cost-benefit-ratio for residential houses compared to grid power that is mostly generated through natural gas. The three major Investor-Owned-Utilities (IOU) in California are: Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E). These IOUs serve customers by zones for municipal areas. The residential sector in California needs power supply for space heating, space cooling, water heating, lighting, cooking, refrigeration, clothes washing, clothes drying, dish washing, freezing, TV, pool pumps, and miscellaneous in two building types (single and multi-family housing) [5]. Projections from studies published by the California Energy Commission indicate that, if household incomes are expected to generally increase at the rate of inflation, energy bills will become less affordable over time [4]. In the white paper on utility costs and affordability [4], a rate forecast is developed that projected a steady growth in customer rates by all three major IOUs. According to the paper, by 2030, bundled residential rates are forecasted to be approximately 12 percent, 10 percent, and 20 percent higher for PG&E, SCE and SDG&E respectively [4].

4. Data Collection and Analysis

4.1. Data Extraction

Based on our literature review our main goal was to identify the efficient and sustainable energy option for homeowners to reduce the cost of energy for them. There are two main kinds of data that we would need to collect in order to reach an informed choice for a better alternative among electric grids as shown in table (1) vs Solar energy with its available financing options.

4.1.1. Electric Grid

Table (1) provides average billing for major states to compare how different states are being charred currently to provide some perspective. Our Electric grid data extraction was mainly based on Southern California Edison’s rates. The rates are mainly based on weather and peak vs non-peak hours and divided among “Tiers” of consumption which has a baseline kWh consumption until which a certain amount is charged, and the rates increase after that baseline. This rate also changes across different regions within California.

Table (1): Average cost of electricity from Jan - June 2022 for major states

STATE	JAN	FEB	MAR	APR	MAY	JUN	Average
Alabama	$100	$104	$110	$113	$110	$110	$108
Alaska	$177	$180	$182	$188	$190	$194	$185
Arizona	$99	$104	$107	$112	$117	$114	$109
Arkansas	$81	$83	$87	$91	$99	$93	$88
California	$161	$161	$160	$112	$161	$164	$153
Colorado	$99	$102	$103	$107	$106	$114	$105
Florida	$105	$103	$102	$100	$98	$100	$102
Georgia	$95	$95	$101	$101	$104	$111	$101
Illinois	$104	$108	$114	$116	$121	$111	$112
Massachusetts	$176	$180	$180	$188	$173	$168	$177

Nevada	$104	$111	$111	$109	$110	$103	$108
New Jersey	$140	$141	$141	$141	$140	$146	$141
New Mexico	$104	$102	$104	$103	$103	$111	$104
New York	$150	$152	$153	$158	$161	$162	$156
Oregon	$92	$94	$94	$95	$98	$98	$95
Texas	$99	$100	$102	$102	$101	$101	$110

4.1.2. Weather and demand-based pricing:

Based on the below data in figures (1.a) and (1.b), summer rates are higher than winter. The main reason for this being as the market prices rise, the suppliers purchasing electricity off the market must pay more for that electricity. It's the same as natural gas in cold weather. That's why electricity rates rise in the summer due to the demand vs supply.[13]

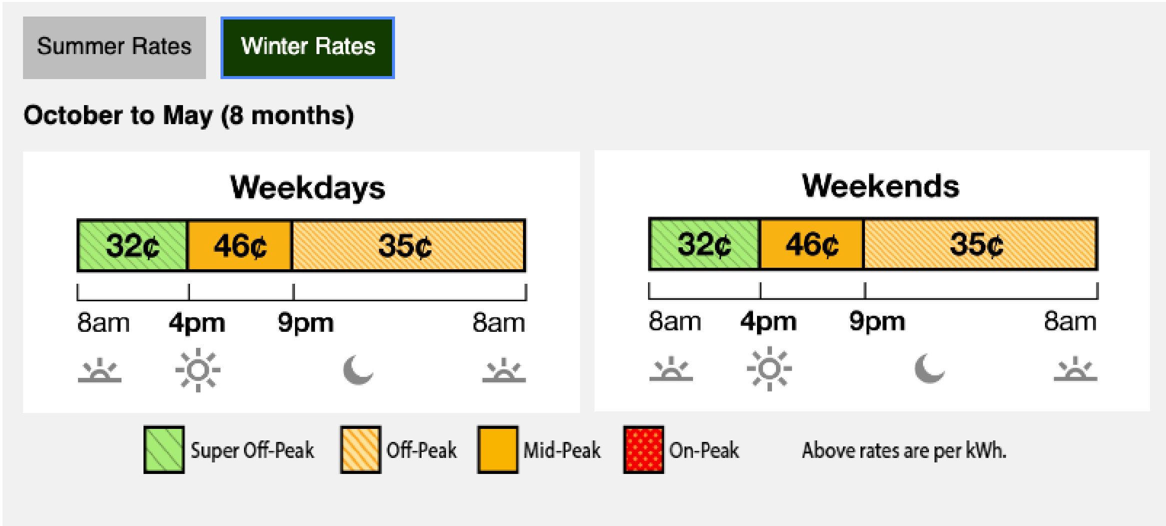


Figure 1.a: Southern California Edison (SCE) Time of Use Winter Rates

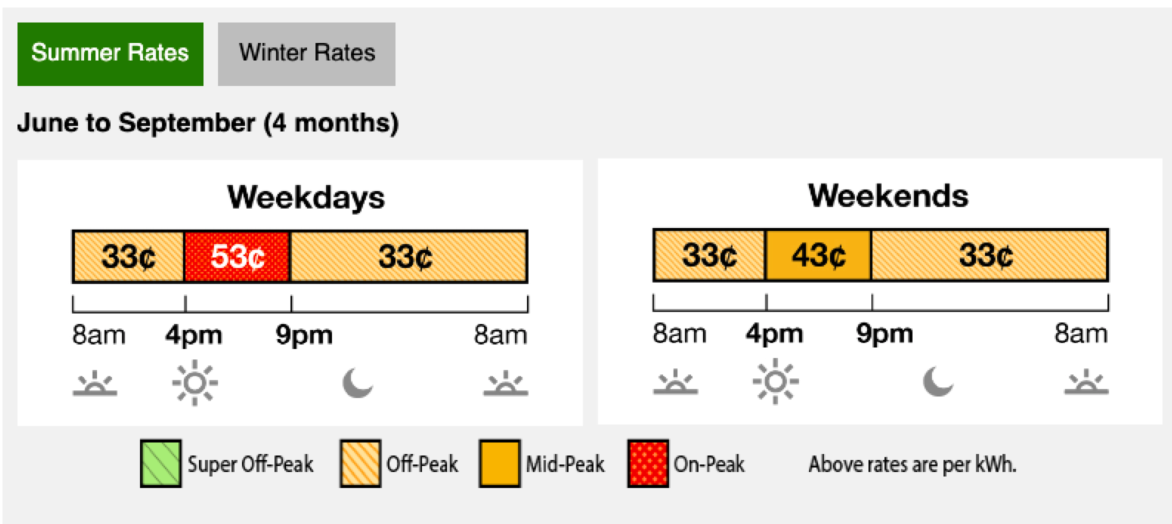


Figure 1.b: Southern California Edison (SCE) Time of Use Summer Rates [13]

The below diagram of figure (2) provides an idea on the 2 main tiers and the high usage tier if the consumer goes overboard with consumption.

Baseline Allocation means the amount of electricity (measured in kilowatt hours) that is provided to households at a lower rate than electricity used above this threshold. Baseline allocations are determined by the California Public Utilities Commission (CPUC) based on the number of days in the billing period, the season, the climate, and whether your primary source of heat is electric. [13]

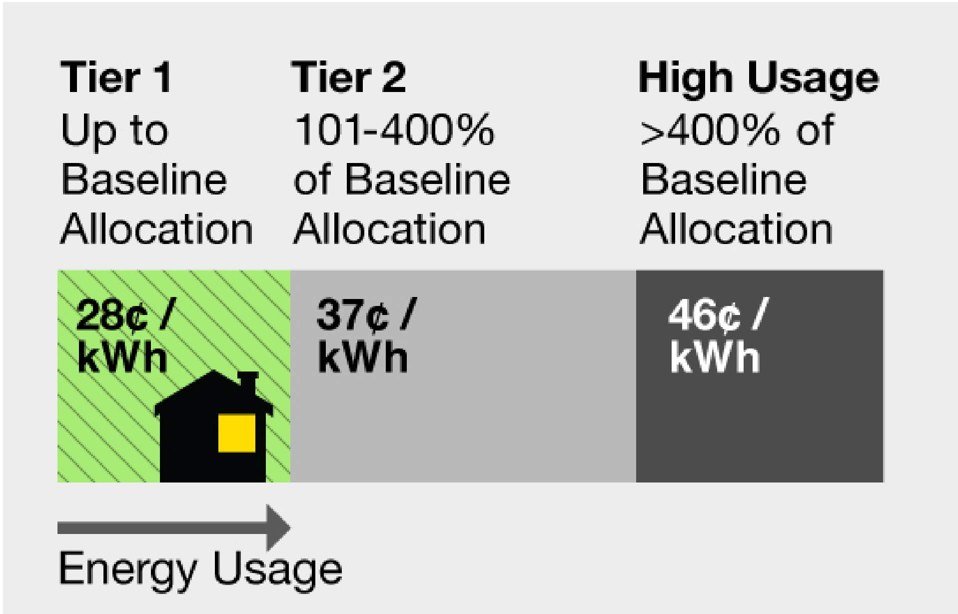


Figure 2: Southern California Edison (SCE) Tiered Rates [13]

Since billing periods can have different numbers of days, the baseline allocation is defined initially as a daily allocation. This is then calculated into an allocation for the entire billing period, which is sometimes called a "Monthly Baseline Allocation" for convenience.

4.1.3. Solar Alternative

For harnessing solar energy to usable power, the two major ways are photovoltaic and Solar thermal capture. First one is mostly associated with small-scale Electricity production whereas the later one is associated with large-scale electricity production. Addition with this solar power is used for heating and cooling. At the time it was also the fastest growing and cheapest source of power in the world which has several economic benefits [7].

Table (2) shows the data extracted from a real-life quote delivered through the Solar Reviews marketplace recently for a typical home in California.

The payback period is relatively short and equates to a much better return on investment than the historical returns that have been available from investing in things like shares or property.

Table 2: The average usage for a house of three people is around 7 kWh.

System size*	Avg cost per watt	Avg system cost (After tax credit) show before tax
4kW	$2.91	$8,602
5kW	$2.81	$10,390
6kW	$2.68	$11,877
7kW	$2.66	$13,763
8kW	$2.68	$15,883
9kW	$2.60	$17,289
10kW	$2.58	$19,077

Levelized cost of power from this typical solar system installed on a home in California over 25 years is 6.0 cents/kWh.

Average cost of utility power over 25 years (if you don't get solar) is 44.0 cents/kWh. This shows that solar is a far cheaper way to power your home in California over the long term. The way we calculate the average cost of utility power is by assuming the current SCE electric rates will grow each year at a compound rate of 3.5% and we deduced this value from our literature review. Actual inflation may be higher or lower than this but either way this analysis shows that solar is a clearly better choice. [6]

California's progressive leadership has done good work in spurring investment in renewable energy. All homeowners are eligible for the federal solar tax credit, and the state offers several incentive programs and solar rebates aimed at further increasing access to reliable, affordable solar panels. However, given the state's ambitious climate targets and the energy burden on most of its population, it could probably do more.

All California residents are eligible for the federal solar investment tax credit, or ITC, for installing PV solar panels and any other eligible solar equipment. Any reputable solar installer will assist in the process of claiming the ITC on your federal tax returns. Claiming the ITC deducts **26%** of the total cost of your solar installation from the taxes you owe.

To be eligible for the solar tax credit, homeowners must own the solar energy system, either having paid for it in cash or by taking out a solar loan. Homeowners who lease solar panels are not eligible to claim the ITC.

4.1.4. California Net Metering Programs

Net energy metering (NEM), or net metering, allows customers to feed the surplus energy generated by their solar panels back to their local power grid in exchange for energy credits from their utility company. As most solar energy systems generate more energy than can be used during the day, this incentive provides homeowners additional savings on their electricity bills and lowers the demand for grid-supplied electricity in the region.

California currently offers a statewide net metering incentive for residents generating electricity with solar panels. Exact credit values will vary based on your utility company. [7]

4.2. Data Analysis

Based on the data that was collected we tried to select specific data that will be used further for our analysis.

4.2.1. Grid Power Lines

Electricity is generated at power plants and moves through a complex system, sometimes called the grid, of electricity substations, transformers, and power lines that connect electricity producers and consumers [7]. SCE is one of the major investor-owned or a private for-profit utility company. It was officially incorporated in 1909 and serves the majority of counties in Southern California including Los Angeles, San Bernardino and Kerns [8]. The utility company charges its customers by two different rate plans: Time of use (TOU) and Tier rates. For TOU rates, the charges vary during winter and summer as shown above on Figures (2), (3) and (4).

In our cost analysis, we picked Tier 1 rates for 2022 and performed calculations based on 28 cents per kWh. Previous rate forecasts indicated that SCE increased their rate at about an annual average of 3.5 percent [6]. We forecasted SCE Tier 1 rates for 11 years starting 2022 with a 3.5 percent increase each year. We assumed that homeowners will not exceed their baseline allowance per day. On this assumption, we calculated the electricity usage for zones 13, 14, 15 which are considered hot areas. These zones cover Los Angeles, San Bernardino and Kern counties [Appendix 2]. The baseline allowances for these zones are listed in Table (3). To avoid skewing the data, we calculated the median of the 3 baseline allowance values and used it as monthly kWh usage for a three-member residential house, See table (3) and (4).

Table 3: SCE Baseline allowances for zones that include high temperature areas

SCE Zone	Daily kWh Baseline Allowance	Monthly kWh Usage
13	22	660
14	18.7	561
15	46.4	1392

- Median Monthly Usage = 660 kWh
- We calculated the utility bill per month and annual energy cost with the following equations:
- Monthly Bill = Electricity Usage per month * kWh rate
- Annual Cost = Monthly Bill * 12

Table 4: Annual SCE electricity bill forecast for 11 years

Year	SCE Tier 1 Rate	Monthly Bill	Annual Cost
2022	0.28	$184.80	$2,217.60
2023	0.29	$191.27	$2,295.22
2024	0.30	$197.96	$2,375.55
2025	0.31	$204.89	$2,458.69
2026	0.32	$212.06	$2,544.75
2027	0.33	$219.48	$2,633.81
2028	0.34	$227.17	$2,726.00
2029	0.36	$235.12	$2,821.41

2030	0.37	$243.35	$2,920.16
2031	0.38	$251.86	$3,022.36
2032	0.39	$260.68	$3,128.14

In this electricity service option, homeowners save the initial costs associated with solar panels. In our study we estimated that cost to be $14,556 after tax credits and rebates. Therefore, if a homeowner stays on distributed power lines that provide electricity from power grids, the annual cash flow in table (5) will include the annual costs of electricity bill and the savings from not installing a solar panel. Cash flow diagram is shown in Appendix 1.

Table 5: Annual cash flow for Grid Power Line

Year	Cash Flow
0	14,556.00
2022	(2,217.60)
2023	(2,295.22)
2024	(2,375.55)
2025	(2,458.69)
2026	(2,544.75)
2027	(2,633.81)
2028	(2,726.00)
2029	(2,821.41)
2030	(2,920.16)
2031	(3,022.36)
2032	(3,128.14)

The cash flow for annual bills is then used to calculate the IRR for the grid power line option. Using the excel spreadsheet formula we got the IRR of 13%. See figure (3).

Cash Flow
14,556.00
(2,217.60)
(2,295.22)
(2,375.55)
(2,458.69)
(2,544.75)
(2,633.81)
(2,726.00)
(2,821.41)
(2,920.16)
(3,022.36)
(3,128.14)
13%
=IRR(B3:B14)

Figure 3: IRR Calculation for Grid Power Line

4.2.2. Solar System

There are 5 primary factors influencing your solar payback period:

1. Average electricity usage for your home, which determines how many solar panels you need
2. Total system cost
3. Solar incentives, rebates, and the federal tax credit
4. Energy production from your solar system
5. Cost of electricity and rate of increase in that cost

Cash flow of Cash Pay:

Figure (4) shows the cash flow of the first option of solar system installation, where the capital cost is paid cash (with an amount of $14,556,), no maintenance cost for 10 years, and annual saving is calculated from grid electricity bills.

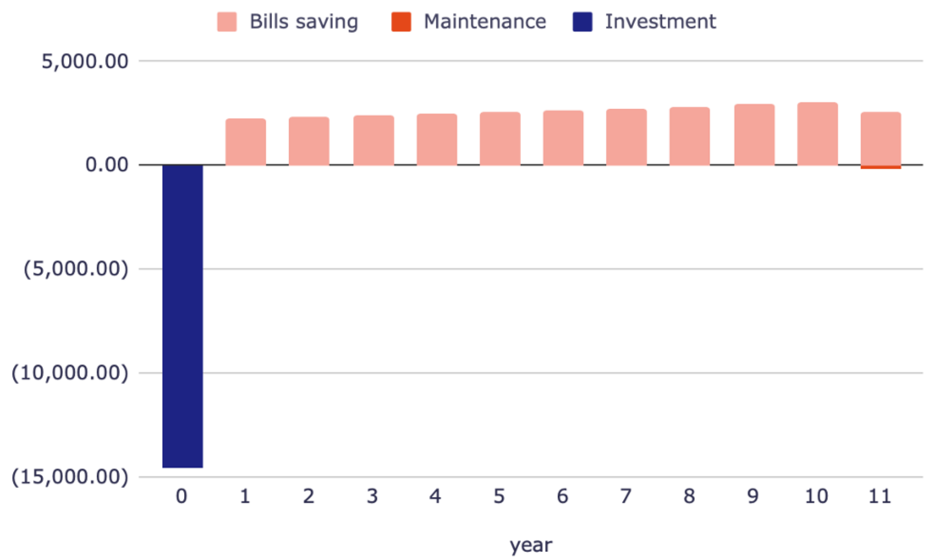


Figure (4) Cash flow- Solar cash payout

For the second option, which is a loan after deduction of ITC, a monthly payment of $491 will be paid for 36 months, no maintenance cost for 10 years, and annual saving is calculated from electricity bills. See figure (5) of cash flow for the loan option after ITC.

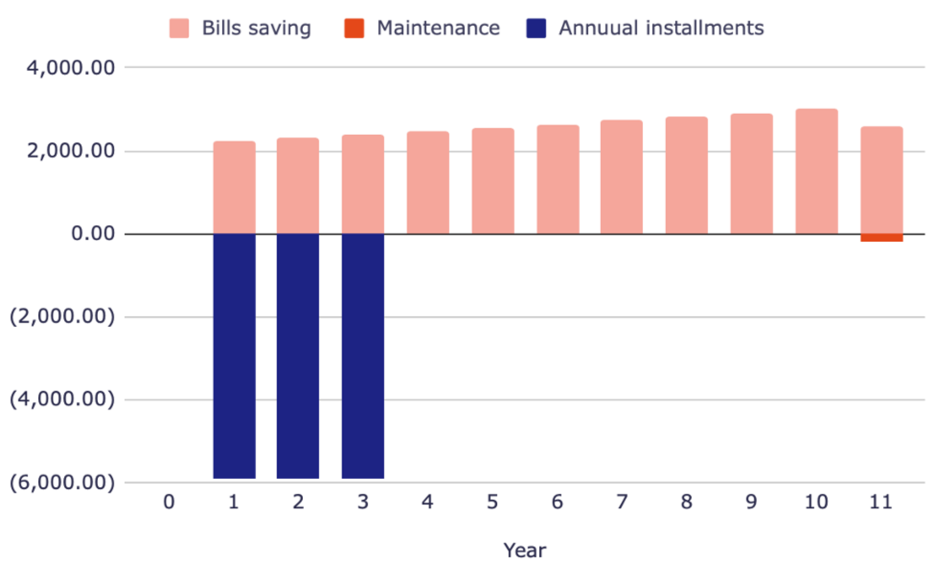


Figure (5): Cash flow- Solar Loan with ITC

For a loan without ITC, which is the third option, figure (6) presents the the cash flow for monthly payment of $619 will be paid for 36 months, no maintenance cost for 10 years, and annual savings is calculated from electricity bills.

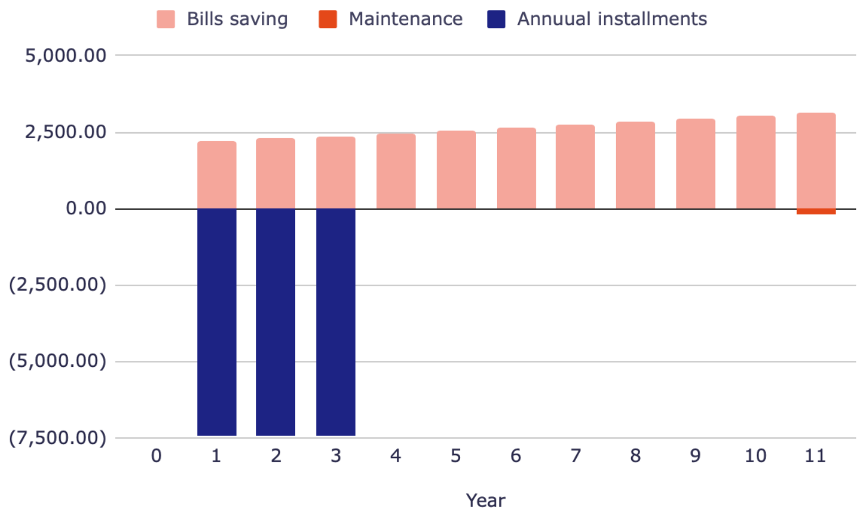


Figure (6): Cash Flow - Solar Loan without ITC

Based on the above assumption and annual cash flows, the communicative PW has been calculated, see table (6), and further economic analysis has been done to conclude with our final recommendation.

Table (6) shows how a 7-kW solar system starts at an estimated total cost of $19,670, which is then reduced by $5,114 because of the federal tax credit and $2,217.60 in electricity bill savings over the first year and so on calculated as per inflation and other factors.

Table 6: The calculations for a home solar panel system in California:

Year	**Maintenance ($)**	**Investment ($)** *($ 19,670 Initial Cost. - $ 5,114 Income tax return. = $ 14,556 Net Cost)*	**PW at 12% ($)**	**Cumulative PW at 12% ($)**
0	0	-14,556.00	-14,556.00	-14,556.00
1	0	2,217.60	1980.01	-12,575.99

2	0	2,295.22	1829.72	-10,746.27
3	0	2,375.55	1690.87	-9,055.40
4	0	2,458.69	1562.55	-7,492.85
5	0	2,544.75	1443.97	-6,048.89
6	0	2,633.81	1334.37	-4,714.52
7	0	2,726.00	1233.10	-3,481.41
8	0	2,821.41	1139.51	-2,341.91
9	0	2,920.16	1053.04	-1,288.87
10	0	3,022.36	973.11	-315.76
11	200.00	2,928.14	841.78	526.02
IRR	13%			

Paying cash for solar unit, above table shows data collection explanations for understanding:
Year column shows the year next from which the unit is purchased. For the same, the data is shown in its associated rows.

Maintenance column shows the investment during the warranty period for the solar unit. Solar units usually come with 10 years of all-inclusive repairs and replacement services. Required repairs and services are as follows which are associated with a unit that comes with a cost associated after the warranty period.

Operational cost includes regular maintenance including:

- Module cleaning
- Vegetation Management
- Component parts replacement, etc.

There are certain possible repair costs associated with solar panels including:

- Loose Wiring
- Hail Damage

- Cracked glass
- Leak, etc.

After the warranty period, approximately $200 yearly is considered from year 11 in the above table.

Investment column shows how the initial investment for a 7Kw unit comes from an actual $19,670 to $14,556. It is the initial investment shown from year 0 or year now. From year 1 onwards to year 11 values are taken from ***table 5*** to consider the savings for each year, which are bill amounts from Grid supply yearly.

PW at the 12% column shows the present value calculated with the help of the TVM factor. These are the savings that are going to be saved in the future (yearly Grid supply bills) each year starting from the investment year and calculations are shown in ***table 9***.

Cumulative PW at the 12% column shows the payback starting period for the solar unit cash investment of $14,556 by reducing the present value of savings from each year. This is how in the 11th year the figure comes as profit.

The savings add up over 11 years, resulting in $526.02 total profit and an IRR of 13%.

4.3. Cost Analysis:

The four alternative power options we deduced for CA homeowners are listed in Table (7).

Table 7: Grid Power Line and Solar Power options for CA homeowners

	Grid Power Line	**Solar Panel: Cash Pay**	**Solar Panel: Loan with ITC**	**Solar Panel: Loan without TC**
Initial Cost	$0.00	-$14,556.00	$0.00	$0.00
IRR	13%	13%	14%	7%

Solar Panel: Loan without TC option has an IRR of 7% which is less than the MARR of 12%. Therefore, we eliminated this option from our incremental analysis. We considered the grid power line option as the base. We performed incremental analysis on the solar alternatives first and excluded the grid power line since this option is mutually exclusive.

4.4. Incremental Analysis:

To perform incremental analysis first we calculated the Annual Savings less expense cost [Table 8]. We ranked the solar power alternatives based on the initial cost. Both alternatives have the IRR greater than the MARR. Examining the incremental investment of alternative B over A, we calculated the IRR of B-A to be 10%, shown in Table (8) and the IRR calculation process is shown in Figure (7).

Table 8: Incremental Analysis of the two Solar Power alternatives

	A	B	B-A
	Solar Panel: Loan with ITC	**Solar Panel Cash Pay**	
Initial Cost	$0.00	-$14,556.00	-$14,556.00
Annual Savings less expense	-$3,674.40	$2,217.60	$5,892.00
	-$3,596.78	$2,295.22	$5,892.00
	-$3,516.45	$2,375.55	$5,892.00
	$2,458.69	$2,458.69	$0.00
	$2,544.75	$2,544.75	$0.00
	$2,633.81	$2,633.81	$0.00
	$2,726.00	$2,726.00	$0.00
	$2,821.41	$2,821.41	$0.00
	$2,920.16	$2,920.16	$0.00
	$3,022.36	$3,022.36	$0.00

	$2,928.14	$2,928.14	$0.00
IRR	14%	13%	10%

B-A
-$14,556.00
$5,892.00
$5,892.00
$5,892.00
$0.00
$0.00
$0.00
$0.00
$0.00
$0.00
$0.00
$0.00
=IRR(D46:D57)

10%

Figure 7: B-A IRR calculation using excel sheet formula.

The cash pay option, B, with the amount of $14556 invested, does not save enough over the 11 years period to produce an IRR that exceeds the MARR: 10% < 12%. Therefore, alternative A wins with a higher IRR of 14% which is greater than MARR 12%.

4.5. Present Worth Method

The incremental analysis produced Solar Panel: Loan with ITC as the best alternative to choose among solar power. We will take this option and do a present worth analysis to compare it with the Grid Power option. These alternatives are mutually exclusive since one option has a loan for three years and the other does not, they have different cash flow for annual bills. However, they provide similar service. Instead of performing incremental analysis we will compare their present worth. Both options do not require capital investments. By comparing present worth we will determine which option is better using a MARR of 12% within a period of 11 years. First, we will calculate the present worth of each annual bill at 12% MARR with the formula:

PW = Annual Bill (P/F, 12% 11)

And then take the summation to compute Total Cost and Net Savings for the Grid Power Line and Solar Panel's Loan with ITC options respectively.

Table 9: Present Worth at 12% for annual bills

Annual Bill	TVM Factor (P/F, 12%, 11)	PW at 12%
$2,217.60	0.89286	$1,980.01
$2,295.22	0.79719	$1,829.72
$2,375.55	0.71178	$1,690.87
$2,458.69	0.63552	$1,562.55
$2,544.75	0.56743	$1,443.97
$2,633.81	0.50663	$1,334.37
$2,726.00	0.45235	$1,233.10
$2,821.41	0.40388	$1,139.51
$2,920.16	0.36061	$1,053.04
$3,022.36	0.32197	$973.11
$2,928.14	0.28748	$841.78
		Total = $15,082.02

As shown in table (9) above, the total PW (12%) value of annual bills, $15082.02, stated in Table 9 is the total cost for Grid Power Line and Net Savings for Solar Panel. The options are summarized in Table (10).

Table 10: Summary of Grid Power and Solar Power: Loan with ITC

	A	**B**
	Grid Power Line	**Solar Panel: Loan with ITC**
Total Cost	-$15082.02	$5892 each year for first 3 years
Net Savings	$14559 (savings from not buying a solar panel)	$15082.02

Maintenance Cost	$0	$200 on year 11

Present Worth at 12%

$PW_{(A)} = -(\sum PW \text{ of annual bill} + \text{maintenance cost}) + \text{Net Saving}$

$PW_{(A)}$ = - $15082 + $14559 = -$523

$PW_{(B)}$ = -(PW of the loan + maintenance cost) + Net Saving

$PW_{(B)}$ = -$5892(P/A, 12%, 3) - 200 + $15082.02 = -$5892*2.4018 -200 + $15082.02 = $730.61

The present worth of base option A [***PW(A)***] is a negative value, therefore, it is not an economically efficient solution for electricity supply. On the other hand, alternative B **[*PW(B)*]**, Solar Panel: Loan with ITC is a positive value of $730.61. Based on these values, we recommend taking a loan with an income tax credit to install solar panels, is the best option for a homeowner to choose for their home's electricity supply.

Long term vs short term viability:

We calculated the PW for Solar Panel: Cash option:

PW (Solar Cash) = -$14559 -200 + $15082.02 = $323.02

The value $323.02 < $730.61 confirms our pick of the service that will save homeowners more on annual electric bills in the long term. However, if a homeowner intends to keep the home for 10 years or less, then grid power lines could be a better option. It has an IRR of 13%, greater than MARR. For the period of ten years the power line option has a positive present worth and the solar power option gets a negative present worth as shown below.

Total of annual bill PW (@12%) excluding the last value of $841.28 = $14240.24 [Table 9]

PW for Grid option at 12% MARR for 10-year period = -$14240.24 + $14559 = $315.75

PW for Solar at 12% MARR for 10-year period = -$5892(P/A, 12%, 3) - 200 + $15082.02= -$111.41

4.6. Break Even Analysis:

Break-even will help us determine when our investment towards Solar installation will reach a point of making it profitable. Before we jump into the calculations let's get some background on the data needed.

Formula:

Initial investment = (total sq foot of solar installation) x (energy generated per sq feet-year) x (cost of electricity / kWh)

Based on the research and previous analysis the average investment comes to be $14,556 for a house of 3 people.

Installable area for solar panels:

Traditional solar panels come in two common configurations: 60-cell and 72-cell, figure (8). The standard dimensions for each option are:

60-cell panels: 39″ x 66″ (3.25 feet x 5.5 feet)

72-cell panels: 39″ x 77″ (3.25 feet x 6.42 feet)

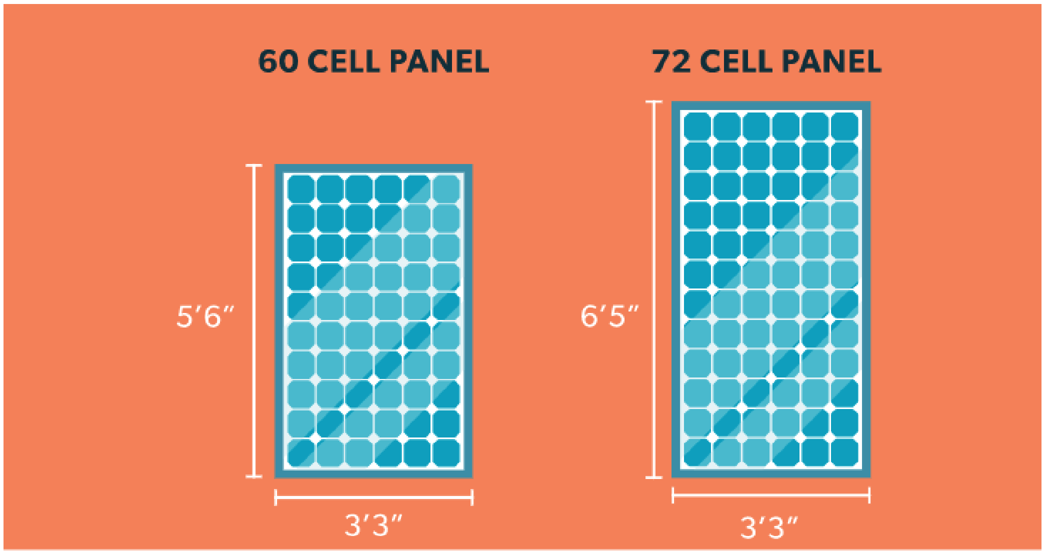


Figure 8: Cell panel configuration

An average-sized solar system will contain 18-23 panels depending on the efficiency of the panels you use.[11]

Here's how that translates to physical system size. Let's compare the least efficient panels (285W / 60-cell) to the most efficient (375W / 72 cell), figure (9), to get a sense for how much space the array might take up:

375W 72-cell panels (9×2 array)

29.25 ft. x 12.83 ft. = 375.38 sq. ft.

285W 60-cell panels (8×3 array)

26 ft. x 16.5 ft. = 429 sq. ft.

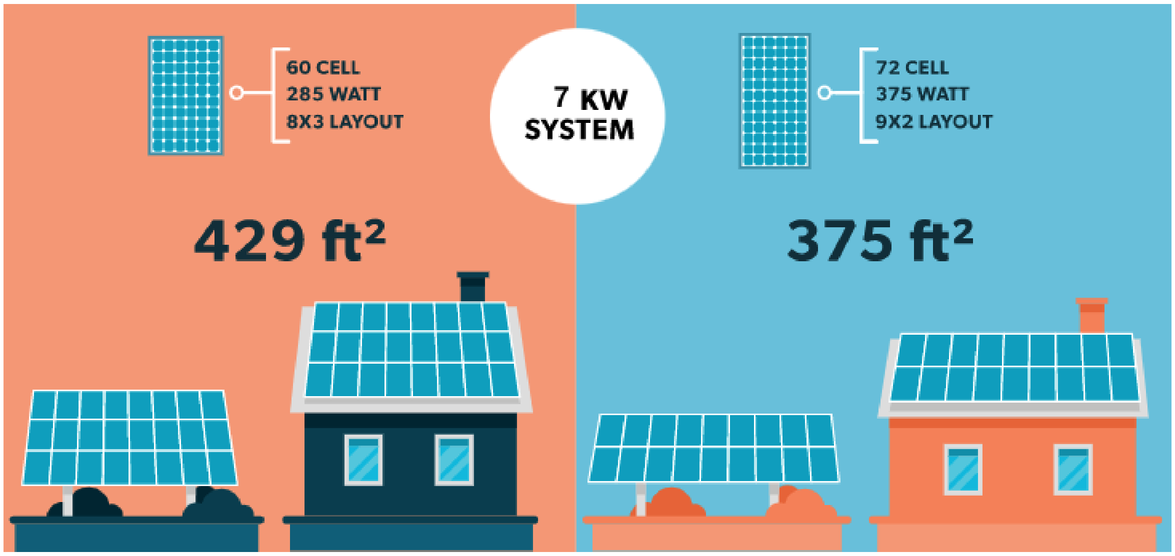


Figure 9: Average square foot solar installable area based on Panel configuration for a house of 3 people

The most commonly used layout is the 72 cell 9x2 panel config which comes to an installable area of **375 Sq feet.** These 72 cell panels usually generate 57-65 kW per panel per sq feet per year which we have averaged out to 57.24 kW.[11]

Based on the electricity rates discussed in earlier sections we will be doing a conservative analysis as to what is the higher threshold at which break even can be attained. The assumption for each kW is 25 cents. Therefore, below the Break even for our 3 main scenarios is calculated.

4.6.1. Scenario 1: Solar installation with Cash payout

Based on the inflation rate from the past decade of 3.5-4% we will assume the compounding percent for our Break even to be 4%. See Tables (11), (12), and (13).

Table (11): Breakeven calculation for Scenario 1

Average roof size 3 person	375
Avg $ per kwh	$0.25

cost of solar installation (in $)	$14,556
Avg energy generation per sq feet	57.24
	14556 = (375 sq foot of solar installation) x (57.24 per sq feet-year) x (0.251 / kWh)
(P/A, i%, X)	2.701701927

With an above TVM factor of 2.7 and 4% it will take 3 years for us to break even

4.6.2. Scenario 2: Solar installation with Loan option and Income Tax Credit

Table (12): Breakeven calculation for Scenario 2

Investment	$14,556
APR %	6.5
Years to repay	3
Loan future worth	$17,681
EMI in $	$491
	17680.760202317 = (375 sq foot of solar installation) x (57.24 per sq feet-year) x (0.251 / kWh)
(P/A, i%, X)	3.281680676

With an above TVM factor of 3.2 and 4% it will take 3.5 years for us to break even

4.6.3. Scenario 3: Solar installation with Loan option and Income Tax Credit

With a lot of debate going on with the mandate the Tax credit may soon be removed by the federal government which is why we tried to see the impacts of the same.

Table (13): Breakeven calculation for Scenario 3

Investment	$18,341
APR %	6.5
Years to repay	3
Loan future worth	$22,278
EMI in $	$619
	22277.7578549194 = (618.826607081094 sq foot of solar installation) x (57.24 per sq feet-year) x (0.251 / kWh)
(P/A, i%, X)	4.134917652

With an above TVM factor of 4.13 and 4% it will take 5 years for us to break even

5. Conclusion

Being in California makes it eligible for some top-notch incentives. With net metering and a large federal tax credit, solar is financially a no brainer. Payback periods for installing solar panels in CA are usually between 5-7 years which is fantastic when you consider the minimum warranted life of solar panels is 25 years. Some of the counties like LA even provide upfront rebate to help cover some of the installation cost of installing solar power. [10]

Considering the above points and the calculations and analyses done during the team project, including incremental analysis, cost benefit or break-even analysis, solar installation for homeowners proves to be a valuable investment on a mid to long term basis.

On the other hand, Solar power systems derive clean, pure energy from the sun. Installing solar panels on your home helps combat greenhouse gas emissions and reduces our collective dependence on fossil fuel. Traditional electricity is sourced from fossil fuels such as coal and natural gas. When fossil fuels are burned to produce electricity, they emit harmful gasses that are the primary cause of air pollution and global climate change. Not only are fossil fuels bad for the environment, but they are also a finite resource. Because of this, the price is constantly fluctuating and can increase in a short period of time.

Although fossil fuel production requires significant water resources and causes water pollution, solar energy requires little to no water to operate. Our cost analysis indicated that it is also an economical option for homeowners. So, not only does solar power not pollute water resources, it also doesn’t put a strain on the world’s water supply and homeowner’s budget.

Solar power also works during a drought or heat wave. Coal, natural gas and nuclear power use large amounts of water for cooling. During heat waves or severe droughts, as we’ve experienced in recent years, electricity generation is at risk. But solar power systems do not require water to generate electricity. [4]

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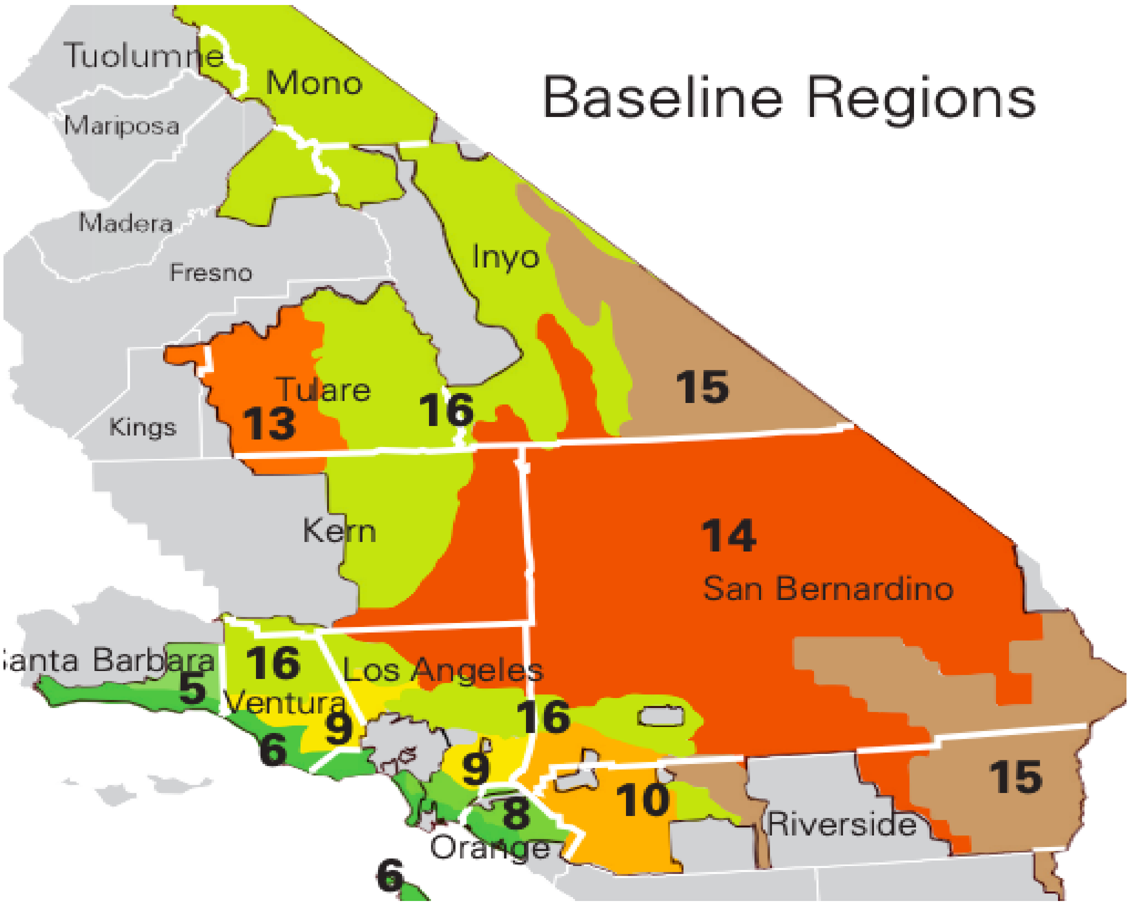
7. Appendixes:

Appendix 1: Cash Flow Diagram of annual electric bills for SCE customer

Appendix 2: SCE Baseline Regions and Zones



Appendix 3: Attached Excel sheet "Final Data Calculations.xlsx" legend

Sheet "Cost Benefit" - Includes cost benefit analysis for Electric Grid option as well as Solar options for 11 years.

- Rows 1-17 represent the cost benefit analysis for Electrical Grid
- Rows 19-30 represent the system costs for Solar installation with and without Tax Credit for different power consumptions
- Rows 32-44 shows the cost analysis for Solar installation with cash payout option
- Rows 46-58 shows the cost analysis for Solar installation with Loan and tax Credit
- Rows 60-72 shows the cost analysis for Solar installation with Loan and without tax Credit

- Rows 73-77 shows different IRR for the cost analysis.
- Rows 97-109 shows the cumulative present worth of our investment

Sheet "Break Even" - break even analysis based on the Solar installation costs based on Chapter 11, Engineering Economy; Sullivan, GW; Wicks, EM; Koelling, CP.

- Rows 1-7 views at the payout option for break-even analysis
- Rows 10-19 views at the loan option with tax credit for break-even analysis
- Rows 25-34 views at the loan option without tax credit for break-even analysis

Sheet "(P/A, i%,X)" - Sheet for TVM factors for Present given Annual worth for all our calculations

Sheet "Incremental Analysis of Solar options" - Provides an overview of the Incremental analysis for Solar option with Cash payout and Loan with Tax credit