Cost Implications of Solar Photovoltaic Systems on Single Family Homes

Prepared For

National Association of Home Builders
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DEFINITIONS AND ABBREVIATIONS

^oF	Degrees Fahrenheit, a unit of temperature.
AC	Alternating Current.
Azimuth	(Compass Direction) The azimuth angle is the compass direction from which the sunlight is coming; it varies throughout the day. At solar noon, the sun is always directly south in the northern hemisphere and directly north in the southern hemisphere. Typically, North = 0° and South = 180°.
BOS	Balance of System.
Buy Rate	The price per kilowatt hour that a utility company pays to a customer to purchase site-generated power for addition to the grid.
Compass Direction	(Azimuth) The east-west compass direction in degrees. A compass direction value of zero is facing north, 90 degrees = east, 180 degrees = south, and 270 degrees = west, regardless of northern or southern hemisphere.
DNI	Direct Normal Solar Irradiance, a measure of the local solar resource.
DC	Direct Current.
GHI	Global Horizontal Solar Irradiance, a measure of the local solar resource.
kW	Kilowatt, A unit of power.
kWh	Kilowatt-hour, A unit of energy equivalent to the energy transferred or expended in one hour by one kilowatt of power.
l.f.	Linear Feet, a unit of length.
Net billing	A system of metering where excess generation is the sum of differences between generation and load in each simulation time step over month; the dollar value of the excess is credited to this month's bill.
Net metering	A system of metering where excess generation is the difference between system's total monthly load: which is "rolled-over" to the next month's bill, effectively reducing the billable kilowatt-hours in that month.
Net Present Value	A project's net present value (NPV) is a measure of a project's economic feasibility that includes both revenue (or savings for residential and commercial projects) and cost.
Normalized Payback	The "simple payback" period (a simulated output from the System Advisory Model) that accounts for the value of electricity generated by the system, installation and operating costs, incentives, income taxes and depreciation, and debt-related costs over the entire analysis period.
NREL	National Renewable Energy Laboratory, a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Period	As part of a utility's electricity pricing arrangement, a time range that defines a unique price for electricity ($/kWh) based on the time of use. Periods can define portions of the day by hour (e.g. day vs. night), or portions of the week by days (e.g. weekend vs. weekday).
PV	Photovoltaics.
ROI	Return on Investment.
Roof slope	The angle or pitch of a roof. Where a PV array is installed on a sloped roof, the array's tilt angle typically matches the roof slope in degrees from horizontal, where zero degrees is horizontal, and 90 degrees is vertical.
SAM	System Advisory Model, A free techno-economic software model that facilitates decision-making for professionals in the renewable energy industry developed by the National Renewable Energy Laboratory (NREL) with funds from the U.S. Department of Energy.
Sell Rate	The price per kilowatt hour that a customer pays to a utility company to draw electrical power from the grid.
Simple Payback	Initial investment cost divided by first-year savings or earnings.
s.f.	Square Feet, a unit of area.
Tier	As part of a utility's monthly electricity pricing arrangement, a usage threshold that defines a unique price for electricity ($/kWh per month) based on the quantity of use on a monthly basis. (e.g. >600 kWh/mo. or >1,000 kWh/mo.).
Tilt	A PV array's angle in degrees from horizontal (0 degrees) where 90 degrees is vertical. When installed on a sloped roof, the array's tilt angle typically matches the roof slope in degrees.

BACKGROUND

The National Association of Home Builders (NAHB) asked Home Innovation Research Labs (HI) to conduct an analysis to determine the typical construction cost, solar energy production, and a range of potential return on investment (ROI) scenarios for a sample of residential photovoltaic solar systems in five different locations. The results are intended to provide region-specific information to assist with examining the implications of code-mandated roof-top solar energy generation for new residential construction.

METHODOLOGY

System Advisory Model (SAM)[1] Version 2018.11.11 was used for the modeling of residential photovoltaic systems for this report. SAM is a techno-economic computer model developed by the U.S. Department of Energy's National Renewable Energy Lab (NREL) designed to facilitate decision making for people involved in the renewable energy industry. The SAM development team collaborates with industry partners, NREL staff and interns, and other research organizations to develop and enhance the model. The original solar models were developed in collaboration with Sandia National Laboratories and the University of Wisconsin's Solar Energy Laboratory.

This report examined five locations: Phoenix, AZ; Tampa, FL; Boston, MA; Kansas City, MO and Seattle, WA. A reference house (Appendix A) was simulated to determine monthly energy profiles for each location. All houses were modeled with all-electric systems, including electric resistance domestic hot water and heat pumps for space heating. Available roof areas were calculated to determine the maximum size PV array that could be mounted on the roof. Solar production simulations were performed on the reference house in each of the five locations using two different roof slopes (6/12 and 9/12) and five different compass directions (east, southeast, south, southwest and west). The system capacities are selected to cover a range from 3 kW (typical introductory system size) to 10 kW (to optimize the reference house roof.)

A summary of design assumptions and a table itemizing the cost per watt of capacity of a roof-mounted solar PV system for the various locations is provided. Final tabular results show the cost effectiveness using various common economic metrics for each configuration analyzed.

In SAM, the photovoltaic (PV watts) performance model and residential (distributed) financial model were selected for this report. The inputs for SAM include location, system design, system costs, system lifespan, financial parameters, electric rates, and electric loads. Incentives were not included in this analysis. Websites for each local utility were referenced for simulation of the actual residential pricing structure and site generation purchasing policies. All locations except Phoenix offer a net metering agreement for buy-back of site-generated electricity from residential customers. The predominant utility for Phoenix offers a net billing agreement. Annual energy production, Normalized Simple Payback and Net Present Value (NPV) for all locations are included as simulation output results from SAM; traditional Simple Payback (yrs) defined as first cost of system / first-cost annual energy production ($/yr), was calculated from other SAM outputs.

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[1] https://sam.nrel.gov/

SUMMARY OF MODEL ASSUMPTIONS

SAM Default Inputs, applied to all simulations:

System Parameters: Design inputs for all locations are listed in Table 1.

Table 1. SAM System Inputs

Model Input	Characteristic	Value
System Design, SAM Defaults	DC to AC Ratio	1.2
	Inverter Efficiency	96%
	Total System Losses	14.08% (shading = 3%)
	Degradation Rate	0.5% per year
	Analysis Period	30 years*
System Design, Project Parameters	Capacity	3kW – 10kW
	Roof pitch	6/12, 9/12
	Compass direction	East, S-east, South, S-west, West
Reference House Characteristics	Floor Area	2,352 s.f.
	Mechanical systems	All electric
	Number of Stories	2
	Number of Occupants	4
	Heating Setpoint	68°F
	Cooling Setpoint	76°F
	Building Energy Modeling	REM/Rate & BEopt

** Chosen to coincide with the length of the typical US home mortgage.*

***Financial Parameters*:** The following NAHB-recommended financial parameters were used as inputs for all locations (Table 2).

Table 2 NAHB-Recommended Financial Inputs

Financial Parameters	Phoenix	Tampa	Boston	Kansas City	Seattle
Average Federal Income Tax Rate	14.13%	12.59%	16.70%	14.60%	16.40%
Average State Income Tax Rate	3.06%	0.00%	5.05%	6.70%	0.00%
Insurance Rate	0.30%	0.74%	0.28%	0.55%	0.21%
Debt Fraction	95%				
Loan term	30 years				
Loan rate	4%				
Nominal discount rate	9.06%				
Annual decline (value of the system)	0%				

Cost

This study focuses on the new construction market only and reflects pricing which includes the cost of the Solar PV system in the house price, and therefore in the financing as well. The cost impacts in this analysis have been developed primarily with data adapted from the following sources: 2019 Residential Cost with RSMeans Data[2]; 2019 Electrical Cost with RSMeans Data; the National Renewable Energy Lab's

[2] https://www.rsmeans.com/

(NREL's) report *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018*[3]; the 2018 California Distributed Generation Statistics[4]; online distributors' websites; confidential estimates to builder for residential rooftop PV systems in Massachusetts; consultants in the residential PV industry in California.

NREL's 2018 Benchmark report was used to define the cost relationships of the various components of a typical residential PV system (Table 3). Total cost is comprised of "hard costs" and "soft costs." Hard costs refer to physical materials like the photovoltaic modules, the inverter and wiring (electrical balance of system) and the mounting system (structural balance of system.) Hard cost varies only marginally by capacity within the 3kW to 10kW range reported here, so a single value is used regardless of system capacity. PV modules and inverters are an international market, so U.S. costs for these individual components are relatively stable nationwide. Soft cost for residential photovoltaic solar systems varies significantly by region due to different jurisdictional policies and local pressures for installation labor and profit, affecting total cost. Soft costs include all costs other than the materials, like permitting, inspection, interconnection fees, installation labor, subcontractor mark-ups, supply chain logistics, sales tax, etc. and can account for over 60% of total system cost. Of these soft costs, only the installation – about 10% of total cost – was adjusted, using RSMeans location factors. National averages were used for other soft costs. It's important to note rebates and incentives were not included in this analysis, neither regional nor federal.

Table 3. 2018 U.S. Benchmark: 6.2-kW Residential System Cost Relationships (NREL)

Cost Category		U.S. Weighted average cost per watt ($)	Proportional Cost
Hard Cost	Modules	0.47	17.4%
	Inverter	0.21	7.9%
	Structural BOS	0.10	3.6%
	Electrical BOS	0.21	7.8%
Soft Cost	Supply Chain Costs	0.30	11.2%
	Sales Tax	0.09	3.3%
	Install Labor	0.27	9.9%
	Permitting, Inspection, Interconnection	0.06	2.1%
	Sales & Marketing (Customer acquisition)	0.35	12.9%
	Overhead (General & Admin.)	0.32	11.7%
	Net Profit	0.33	12.3%
	∑ Total Cost	**2.70**	**100.0%**
	Hard cost	**0.99**	**36.6%**
	Soft cost	**1.71**	**63.4%**

Two different cost resources have been used in this analysis to establish upper and lower bounds for a range of reasonable ROIs. The high-end PV $/W$_{DC}$ cost estimate uses the 2018 California Distributed Generation Statistics[5]. The reported average of $4.57/W$_{AC}$ for residential systems was converted to $3.81 W$_{DC}$ using the NREL-established conversion factor of 1.2, and then normalized to a national average of $3.74 by adjusting the 10% installation portion (per NREL discussion) by the median California location factor of 1.22 (RS Means).

[3] https://www.nrel.gov/docs/fy19osti/72399.pdf
[4] https://www.californiadgstats.ca.gov/charts/
[5] https://www.californiadgstats.ca.gov/charts/

The low-end estimate uses NREL's Q1 2018 Benchmark US average total cost of \$2.70/ W_{DC}. The installation portions of both the high and the low national average PV costs were then adjusted using RS Means location factors for each of the cities analyzed in the report. The high and low pricing which define this report's analysis range encompasses several other 2018 national median installed PV system benchmarks for residential, host-owned PV systems (Figure 1), including Berkeley Lab's Tracking the Sun report[6] (\$3.70/W_{DC}), the Solar Energy Industries Association (SEIA) U.S. Solar Market Insight[7] (\$3.00/W_{DC}), and several online PV system pricing tools.[8, 9, 10]

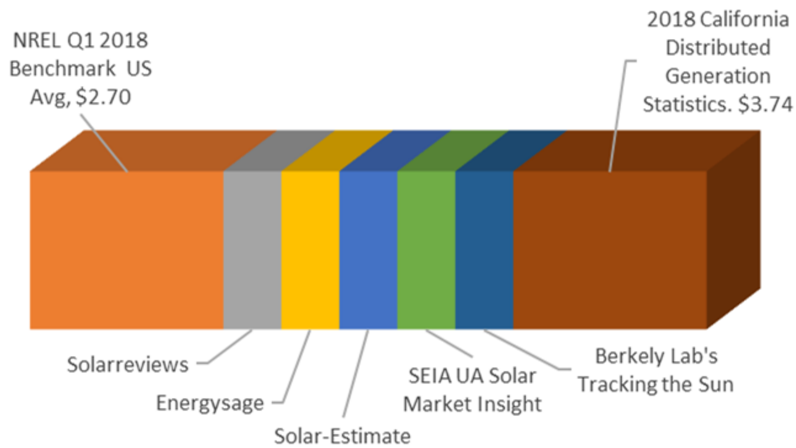


Figure 1. Range of Commonly Referenced PV Pricing Benchmarks, National Average

Since the premise of this analysis is that solar is included with the new home at the point of sale, the Total Cost to Consumer includes a builder's gross margin of 18.9% per NAHB's 2014 *Cost of Doing Business Study*[11]. Regional cost per watt for residential photovoltaic solar systems offered to home buyers by builders can differ from the national average by up to 20%.

[6] https://emp.lbl.gov/tracking-the-sun
[7] https://www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/#gs.BLbjX=w
[8] https://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/
[9] https://www.solarreviews.com/solar-panels/solar-panel-cost/#offers-in-your-city
[10] https://www.solar-estimate.org/
[11] http://eyeonhousing.org/2016/03/whats-the-average-profit-margin-of-single-family-builders/

Table 4. State Specific Cost Per Watt of Photovoltaic Solar System, Total Cost to Consumer

State	Location factors - residential (RS Means)	Labor cost	Total Cost per watt	Total Cost per watt w/Builder Margin[1]	Labor cost	Total Cost per watt	Total Cost per watt w/ Builder Margin[1]
		Low-end Estimate			High-end Estimate		
National Average	**1.00**	**$0.27**	**$2.70**	**$3.53**	**$0.37**	**$3.74**	**$4.45**
Phoenix, AZ	0.87	$0.23	$2.66	$3.17	$0.33	$3.69	$4.39
Tampa, FL	0.81	$0.22	$2.65	$3.15	$0.30	$3.67	$4.36
Boston, MA	1.18	$0.32	$2.75	$3.27	$0.44	$3.81	$4.53
Kansas City, MO	1.02	$0.28	$2.71	$3.22	$0.38	$3.75	$4.46
Seattle, WA	1.05	$0.28	$2.71	$3.23	$0.39	$3.76	$4.47

1. Builder's gross margin of 18.9% is used.

Energy Load Profile

HI defined a representative size and configuration for a typical single-family house ("reference", Appendix A). This reference house was then modified for each location to be compliant with the 2018 International Energy Conservation Code (IECC) minimum prescriptive requirements for the climate zone and to represent the predominant foundation and wall types based on housing starts in each area, per HI's Annual Builder Survey (Appendix B). All houses were modeled with electrical equipment for all uses, including heating and water heating. Annual whole-house energy loads in [kWh] were simulated using energy tools REM/Rate and BEopt for input into the SAM simulation engine (Table 5).

Table 5. Annual Energy Load for Given Reference House in Various Locations (kWh)

			State		
Month	**Phoenix, AZ**	**Tampa, FL**	**Boston, MA**	**Kansas City, MO**	**Seattle, WA**
January	1180	1162	3819	3853	2638
February	1025	1054	3564	3196	2286
March	950	987	3099	2424	1926
April	1118	1071	2307	1487	1624
May	1273	1228	1448	1314	1359
June	1882	1350	1074	1471	1185
July	2174	1403	1098	1807	1218
August	1956	1385	967	1495	1135
September	1677	1312	1034	1199	1110
October	1292	1277	1587	1471	1595
November	944	963	2554	1356	2021
December	1000	1080	3270	3105	2419
Total Annual Load	**16,471**	**14,273**	**25,820**	**24,178**	**20,515**

Optimal System Size

For each location, optimal size with reference to annual energy load was calculated using SAM to determine the PV capacity required to achieve a "net zero" condition, where annual energy production would equal annual energy use. This size is not necessarily optimal for payback, however, because ROI depends on many other factors, including the concurrence of use and production.

Table 6 shows the maximum capacity that can fit on the roof of the reference house, determined using a Panasonic 330W Module as typical – about 12 kW total PV capacity. At 9/12 roof slope the reference house has 750 sf facing the predominant direction. Applying a 12% safety factor yields 660 sf usable roof area. At 6/12 roof slope the reference house has 671 s.f. facing the predominant direction and a 12% safety factor yields 590 s.f. usable area. For each location studied, two system sizes are reported in the summary. The smallest, 3 kW, is a typical entry point; the largest system, 10 kW, maximizes the roof area for a large portion of US houses. The full range of results is shown in the Appendices.

Table 6. PV Capacity Optimized for Reference House Roof Area

Aspect	Value
Area of single panel (S.F)	18.02[12]
Capacity of single panel (Watts)	330
Available roof area, ref house for 9/12 roof slope, incl. 12% safety factor (s.f.)	660
Maximum capacity, ref with 9/12 roof (Kilowatts)	12
Available roof area, ref house for 6/12 roof slope, incl. 12% safety factor (s.f.)	590
Maximum capacity, ref with 6/12 roof (Kilowatts)	11

Table 7 shows the results from SAM for a 10kW PV system for each location. Figure 2 illustrates the solar resource in each location.

Table 7. 10kW Capacity and % Load Covered

State	Annual Energy Load (kWh)	Capacity Required to Achieve Net Zero	Number of Panels required for Net Zero	Least Roof Area, s.f. Required for Net Zero	Maximum Capacity simulated for Summary Graph	Energy Produced by Optimized System Size Year 1 (kWh)	% Load Covered by Optimized System
Phoenix, AZ	16,471	10 kW	31	559	10 kW	17,323	105%
Tampa, FL	14,273	10 kW	31	559	10 kW	15,670	110%
Boston, MA	25,820	19 kW	58	1045	10 kW	16,155	53%
Kansas City, MO	24,178	17 kW	52	937	10 kW	17,545	60%
Seattle, WA	20,515	18 kW	55	991	10 kW	14,304	58%

[12] https://tandem-solar-systems.com/buy-solar-products/panasonic-330w-module-blkwht/?gclid=EAIaIQobChMI5YCHzu3s5AIVjrbICh0xIAasEAkYASABEgIfBvD_BwE

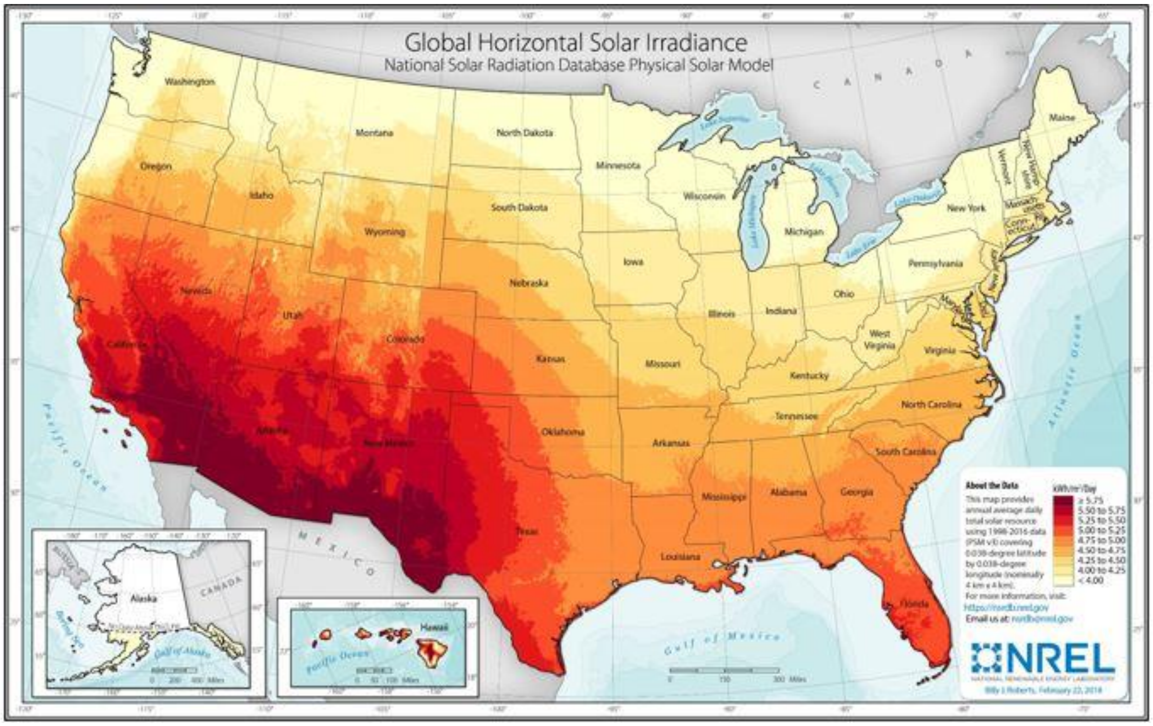


Figure 2. Relative Global Horizontal Solar Irradiance [13]

RESULTS AND ANALYSIS

ROI Metrics

Financial outputs and their definitions are shown in Table 8.

Table 8. ROI – Outputs and Descriptions

Output	Description
Energy Produced (Yr 1)*	Energy (kWh) produced by the system in the first year.
Value of Energy Produced (Yr 1)*	The value ($) of the Energy produced by the system in the first year.
Simple Payback (Years)	The initial cost of investment divided by the first year of savings.
Normalized Simple Payback*	The payback period that accounts for the value of electricity generated by the system, installation and operating costs, incentives, income taxes and depreciation, and debt-related costs over the life of the system.
Net Present Value (NPV)*	A project's net present value (NPV) is a measure of a project's economic feasibility that includes both revenue (or savings for residential and commercial projects) and cost. The NPV is given by the relation: $\mathrm{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1 + d_{nominal})^n}$ Where C_n is the after-tax cash flow in Year n for the model, and the after-tax project returns, N is the analysis period in years, and $d_{nominal}$ is the nominal discount rate ($d_{nominal}$ = 9% for all results in the Appendices).
*This value is a SAM simulation output.	

[13] https://www.nrel.gov/gis/images/solar/solar_ghi_2018_usa_scale_01.jpg

Sample ROIs for a 3 kW and a 10kW system for Phoenix, AZ are shown in Table 9. Note that the least challenging metric to meet is the traditional Simple Payback Period (system cost/year 1 savings), followed by the Normalized Simple Payback Period, which additionally accounts for panel degradation and operating costs over the lifetime of the system. NPV is the most difficult metric given that it also factors in the cost of money. Simple Payback is highly sensitive to PV incentives that reduce first-cost. Both Normalized Simple Payback and NPV are sensitive to cash flows, future energy cost, $d_{nominal}$, and tax-related incentives (which were not considered in this analysis).

Table 9. Sample ROI Outputs (Phoenix, AZ, 3kW and 10kW)

Phoenix, AZ					**Low End Cost ($3.17/Watt)**			**High End Cost ($4.39/Watt)**		
Size kW	**Tilt**	**Az.**	**Energy Prod., kWh, Yr 1**	**Value of Energy $, Yr 1**	**Normal-ized Payback Period, years**	**Net Present Value**	**Simple Payback Period, Years**	**Normal-ized Payback Period, years**	**Net Present Value**	**Simple Payback Period, Years**
3	6/12	E	4410	$474	23.4	-1391	20.1	*	-3767	27.8
		SE	4986	$543	20.0	-533	17.5	27.3	-2909	24.2
		S	5092	$598	17.9	140	15.9	24.5	-2236	22.0
		SW	4705	$603	17.8	186	15.8	24.4	-2190	21.9
		W	4048	$559	19.4	-355	17.0	26.6	-2731	23.5
	9/12	E	4276	$443	25.4	-1767	21.5	*	-4143	29.8
		SE	4983	$523	20.9	-784	18.2	28.5	-3160	25.2
		S	5105	$591	18.2	56	16.1	24.8	-2320	22.3
		SW	4632	$600	17.9	160	15.8	24.5	-2216	21.9
		W	3835	$551	19.8	-459	17.3	27.0	-2835	23.9
10	6/12	E	14700	$1,115	*	-10126	28.4	*	-18046	39.4
		SE	16621	$1,269	29.5	-8182	25.0	*	-16101	34.6
		S	16974	$1,401	26.2	-6496	22.6	*	-14416	31.3
		SW	15683	$1,409	25.9	-6366	22.5	*	-14285	31.2
		W	13493	$1,342	27.4	-7204	23.6	*	-15123	32.7
	9/12	E	14252	$1,027	*	-11243	30.9	*	-19163	42.8
		SE	16610	$1,213	*	-8900	26.1	*	-16819	36.2
		S	17016	$1,387	26.5	-6683	22.9	*	-14602	31.7
		SW	15440	$1,397	26.2	-6525	22.7	*	-14445	31.4
		W	12785	$1,309	28.2	-7614	24.2	*	-15534	33.5

*Indicates payback period exceeds analysis period

Nominal Discount Rate Sensitivity

A project's net present value (NPV) is a measure of a project's economic feasibility that includes both revenue (or savings for residential and commercial projects) and cost. The NPV is given by the relation:

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1 + d_{nominal})^n}$$

Where

C_n is the after-tax cash flow in year n for the model
N is the analysis period in years
$d_{nominal}$ is the nominal discount rate

A sensitivity study was performed to determine the effect of Nominal Discount Rate (NDR) on NPV. A sample of outputs for all locations in a range of azimuths for a 3 kW PV system with a 6/12 roof angle and low-end system pricing is shown in Table 10 for NDRs of 6%, 9% and 12%. NPVs reported in the Appendix used a nominal discount rate of 9% (SAM's default value) for the full range of locations, system pricing, sizes, tilts, and azimuths.

Table 10. Sample NPV Results: Sensitivity Study for Variable Nominal Discount Rate (NDR)

Compass Direction		E	SE	S	SW	W
Location	$d_{nominal}$	Net Present Value (NPV)				
Phoenix	6%	-1550	-349	593	656	-104
	9%	-1391	-533	140	186	-355
	12%	-1269	-614	-99	-64	-476
Tampa	6%	-2084	-1310	-1111	-1551	-2424
	9%	-1789	-1236	-1093	-1408	-2031
	12%	-1583	-1160	-1051	-1291	-1767
Boston	6%	2497	4555	5343	4462	2386
	9%	1490	2962	3526	2896	1411
	12%	924	2049	2480	1998	864
Kansas City	6%	-3549	-2678	-2321	-2605	-3457
	9%	-2827	-2204	-1949	-2152	-2761
	12%	-2371	-1894	-1699	-1854	-2320
Seattle	6%	-4422	-3528	-3127	-3404	-4245
	9%	-3464	-2824	-2537	-2735	-3337
	12%	-2864	-2375	-2156	-2308	-2767

NPV is dependent on cash flow, which is in turn a function of the nominal discount rate. In this study, the difference between $d_{nominal}$ = 6% or $d_{nominal}$ = 12% can mean the difference between a negative or a positive NPV. Table 11 shows example annual cash flows for the 30-yr analysis period for all locations for a 3 kW PV system facing due south with a 6/12 roof angle and low-end system pricing using $d_{nominal}$ = 9%. An example financial report for the entire 30-year analysis period for Phoenix, AZ is included in Appendix C for the detailed illustration of financial metrics.

Table 11. Sample Annual Cash Flows for all locations

Year	Phoenix	Tampa	Boston	Kansas City	Seattle
0	-476	-473	-491	-483	-485
1	-20	-128	253	-192	-245
2	-12	-121	268	-187	-240
3	-4	-114	282	-182	-235
4	5	-107	297	-176	-231
5	14	-100	312	-171	-226
6	23	-92	327	-165	-221
7	32	-85	343	-160	-216
8	41	-77	359	-154	-211
9	50	-69	375	-149	-206
10	60	-61	391	-143	-201
11	69	-53	408	-137	-195
12	79	-45	425	-131	-190
13	89	-37	442	-125	-185
14	99	-28	460	-120	-180
15	109	-20	477	-114	-174
16	120	-11	495	-108	-169
17	130	-2	514	-101	-163
18	141	7	532	-95	-157
19	152	16	551	-89	-152
20	163	25	571	-83	-146
21	174	34	590	-77	-140
22	185	43	610	-70	-134
23	196	53	631	-64	-129
24	208	63	651	-57	-123
25	220	73	672	-51	-117
26	232	83	693	-44	-111
27	244	93	715	-38	-104
28	256	103	737	-31	-98
29	268	113	759	-25	-92
30	281	124	781	-18	-86

Utility Policies Regarding Site Generation of Electricity

Comparison between different locations with different resources, different energy loads and different utility agreements is challenging. An additional challenge includes locations for which the arrangement with the utility changes from one year to the next. For instance, in February of 2017 the Arizona Corporation Commission voted to end the previous net metering arrangement[14], to be replaced by net billing following a three-year transition period. Customers with solar systems in place or permitted by July 1, 2017 were grandfathered in, and the next three annual tranches of customers installing PV

[14] https://www.greentechmedia.com/articles/read/arizona-vote-puts-an-end-to-net-metering-for-solar-customers#:~:text=Arizona%20Vote%20Puts%20an%20End%20to%20Net%20Metering%20for%20Solar,rates%20for%20only%2010%20years.

systems were guaranteed minimum electricity sell rates for a 10-year period. Customers with systems permitted after that were subject to the new net billing arrangement. For context, Table 12 shows the relative differences in Phoenix's utility arrangements prior to and since the 2017 change.

Table 12. Summary of Recent Changes to Utility Arrangements in Phoenix, AZ

Net Metering pre-2017

Sell = Buy, per kWh	Summer	Winter
On-Peak	$0.08683	$0.06376
Off-Peak	$0.05230	$0.05230

Net Billing Transition* 2017 – 2019

Cust buys from Utility, per kWh	Summer	Winter
On-Peak Energy Charge	$0.24314	$0.23068
Off-Peak Energy Charge	$0.10873	$0.10873
Super Off-Peak Energy Charge		$0.03200

Cust sells to Utility, per kWh		ALL
Tranche 2017	September 1, 2017 through September 30, 2018	$0.1290
Tranche 2018	October 1, 2018 through August 31, 2019	$0.1161
Tranche 2019	September 1, 2019 through August 31, 2020	$0.1045

* Purchase rates (customer sell rates) determined as follows (summarized):

1. The RCP rate for each successive tranche may not be reduced by more than 10% each year.
2. Qualification for tranche will be based on the RCP in effect at the time of system application.
3. Each Customer's initial RCP rate will be applicable for 10 years from the time of their interconnection.
4. Following this period the purchase rate will be as in effect at that time and may change from year to year.

Net Billing 2020 and after *(values used to produce the results in this analysis)*

Cust sells to Utility, per kWh	Summer	Winter
On-Peak	$0.02989	$0.03040
Off-Peak	$0.02897	$0.02831

Cust buys from Utility, per kWh	Summer	Winter
On-Peak	$0.26785	$0.25407
Off-Peak	$0.11927	$0.11927
Super off-Peak		$0.03445

The current APS net billing arrangement also includes an on-site distributed generation charge of $0.93 per kW_{DC} of nameplate capacity. This "grid access charge" ranges from $2.79/mo for a 3kW system to $9.30/mo for a 10kW system. Only customers with onsite electricity generation systems pay this charge, whereas all customers pay a fixed monthly charge of $12.81, similar to other cities studied in this report. Adding even more complexity, Arizona also offers four different rate structures for customers, evidently using demand charges to incentivize user behavior.

The first two pages of ROI summaries in this section provide graphical comparison between all locations for both system pricing categories (low and high). For all analyses, "buy" means the residential customer purchases electricity from the utility; "sell" means the residential customer sells site-generated electricity to the utility. The utility often assigns separate energy prices depending on whether the customer ‘buys’ or ‘sells’. Typically, the ‘sell’ rate is lower than the ‘buy’ rate, to account for the cost of distribution and other overhead costs. Sometimes this rate is called the “net avoided cost.”

Net metering accounts for excess generation on a monthly basis and the meter is allowed to “run backward.” At the end of the month the utility “rolls over” any net excess to the following month as an energy credit. If the credit is in energy units (kWh) the customer can essentially “bank” the retail value of all excess energy, though there may be a conversion to dollars ($) at the end of the year at a set price per the metering agreement. Some utility arrangements convert the excess electricity production to dollars ($) on a monthly basis, again at a predetermined sell rate, and that credit is applied to the following month’s bill. The conversion usually considers time-of-use (TOU) or tiered rates. Net billing considers time steps (hourly) over the month, rather than the total monthly load. Another approach is sometimes called “buy all / sell all,” which means that purchased energy and site-generated energy each are assigned discrete prices. This method requires two meters.

The most generous of these arrangements is net metering with energy credits (kWh) because when the PV system produces more than the building consumes, the direct offset means the customer essentially earns retail rates for site electricity production, month after month. The end-of-year reckoning typically has a small impact. The differential between the end-of-month buy and sell rates for net metering with $ credits means that the overage in each month is converted to a lower rate, reducing the savings. The addition of TOU and tiered rates further eats into savings. Net billing additionally includes the time step comparison, further reducing savings. Buy all/sell all is typically the least advantageous arrangement for the customer because all energy produced by the site generation system is sold at rates that are often much lower than the rate at which the customer buys energy from the utility.

In this study, Phoenix is the only location that uses net billing; net metering is the site-generated energy purchasing arrangement for all other locations. Seattle and Tampa have net metering with energy credits; Boston and Kansas City have net metering with $ credits. None of the cities studied here use “buy all/sell all.”

The utilities in Phoenix, Boston and Kansas City identify periods with unique pricing by hour, day of the week and even season. This allows them to incentivize periods for production of energy or for energy efficiency, and to price in relation to demand. Tampa, Kansas City and Seattle utilities enforce a tiered arrangement where monthly energy use exceeding a pre-determined maximum (1,000 kWh, 1,000 kWh, 600 kWh, respectively) is billed at a higher rate.

PDFs of utility rate structures applied in all simulations are included in the Appendix.

Simple Payback Summary Results – Low System Pricing

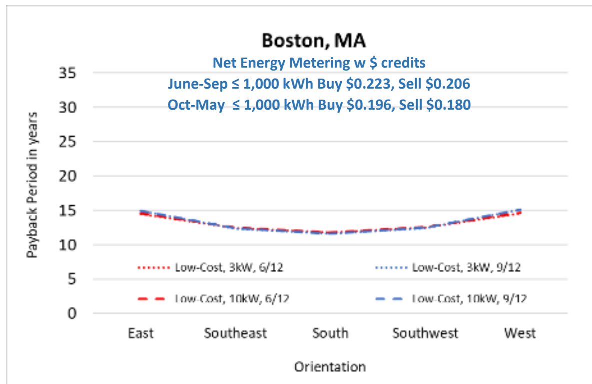
CITY	Low-Cost System	CZ	LATITUDE	Solar Resource GHI (kWh/m^2/day)	Annual Load, KWh
Phoenix	$3.17	2	33.4° N	5.79	16,471
Tampa	$3.15	2	27.9° N	5.22	14,273
Boston	$3.27	5	42.3° N	4.06	25,820
Kansas City	$3.22	4	39.0° N	4.38	24,178
Seattle	$3.23	4M	47.6° N	3.47	20,515

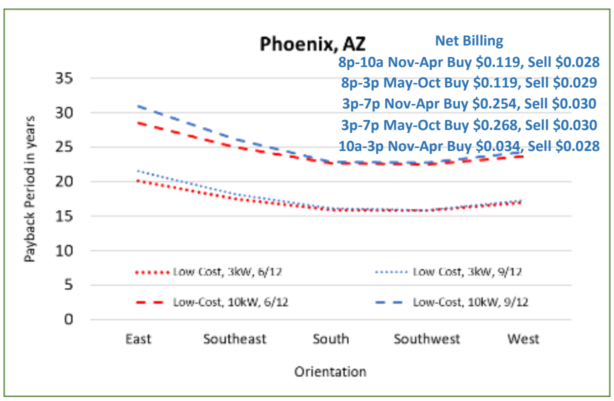
Above: System Cost per kW of capacity, Climate Zone, Latitude, Global Horizontal Solar Irradiance (solar resource), and Simulated Annual Load for All Locations

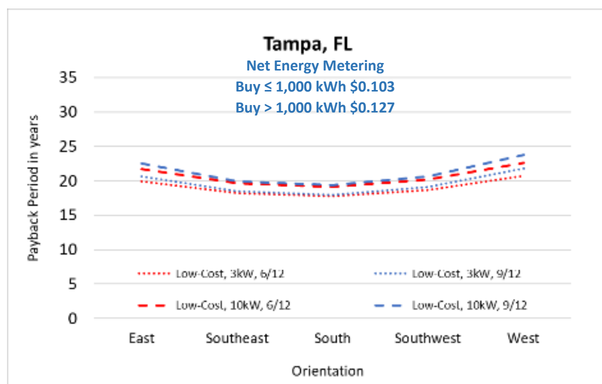
Buy: residential customer purchases electricity from the utility

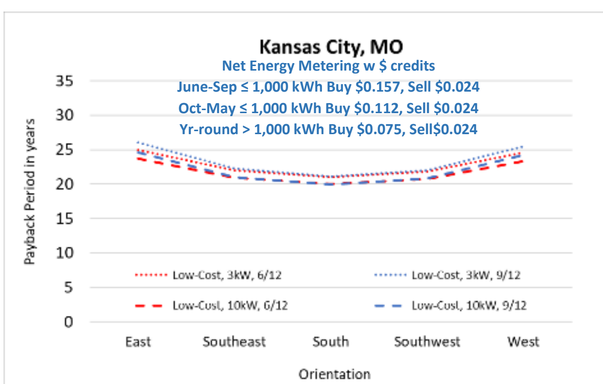
Sell: customer sells site-generated electricity to the utility (or is credited for net excess generation)

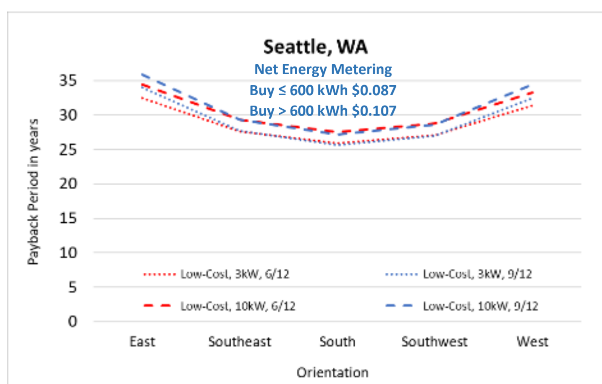
Simple Payback (Years)= 1st Cost/ 1st yr Cash Flow











Simple Payback Summary Results – High System Pricing

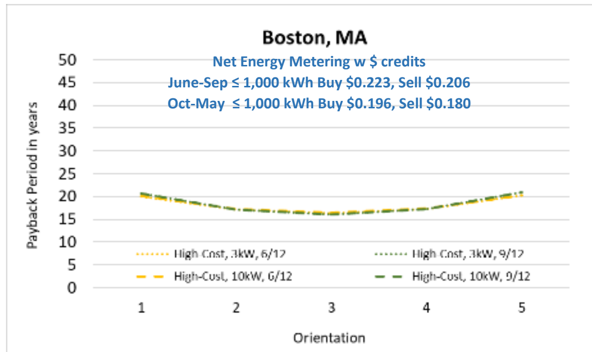
CITY	High-Cost System	CZ	LATITUDE	Solar Resource GHI (kWh/m²/day)	Annual Load, KWh
Phoenix	$4.39	2	33.4° N	5.79	16,471
Tampa	$4.36	2	27.9° N	5.22	14,273
Boston	$4.53	5	42.3° N	4.06	25,820
Kansas City	$4.46	4	39.0° N	4.38	24,178
Seattle	$4.47	4M	47.6° N	3.47	20,515

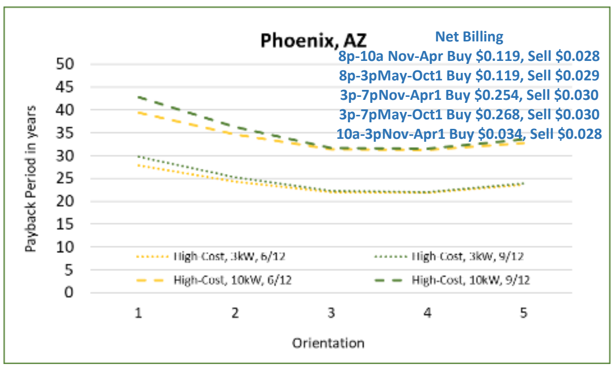
Above: System Cost per kW of capacity,
Climate Zone, Latitude,
Global Horizontal Solar Irradiance
(solar resource), and
Simulated Annual Load for All Locations

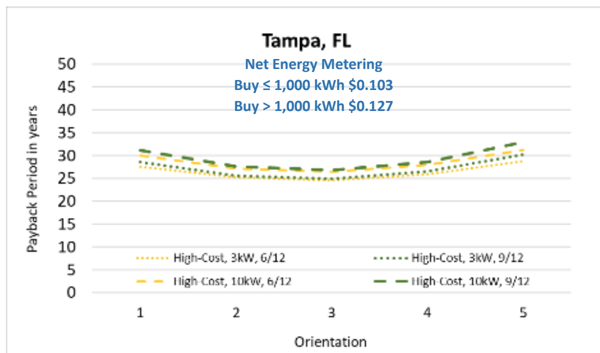
Buy: residential customer purchases electricity from the utility

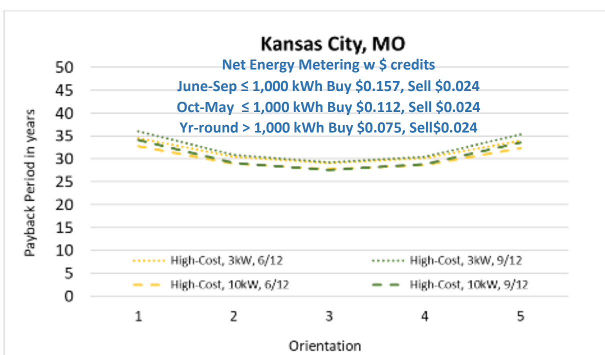
Sell: residential customer sells site-generated electricity to the utility

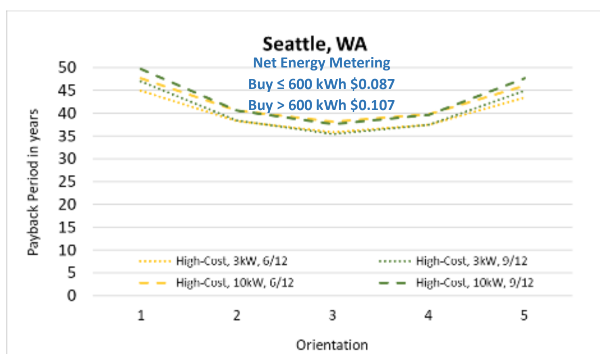
Simple Payback (Years)= 1st Cost/ 1st yr Cash Flow











A few overarching themes are apparent:

1. Depending on the location and utility arrangement, the \$1.21/kW_{DC} price differential between the low and high cost systems studied can add up to 8 years to the simple payback period.

2. The PV system's azimuth (compass orientation) is a key indicator of cost-effectiveness and can add up to 12 years to the simple payback period. The tilt (roof slope) has a small effect.

3. The 'normalized' simple payback – a metric calculated by SAM – is 2 to 7 years longer than the simple payback (system cost/first year savings).

4. ROI is highly dependent on electricity pricing. Higher relative pricing for any utility arrangement and any system design improves cost effectiveness.

5. ROI is highly dependent on metering arrangements; system size can trigger major differences.

    a. Net metering arrangements which allow the customer with site-generation to "run the meter backwards" and carry forward energy credits mean the PV system earns retail rates for excess electricity. System size has little effect on cost-effectiveness under this scenario.

    b. Net metering with \$ credits (discounted sell rates monthly) and net billing arrangements (which account for excess generation on a time-step basis) provide less opportunity for concurrent offsets, and make it more likely that excess generation is valued at a lower 'sell' rate. An over-sized system (whose peak generation frequently exceeds usage) is significantly less cost effective in this case (see Phoenix results) because a larger portion of energy production is valued at a relatively low rate.

6. Net metering with a single period provides reasonable symmetry according to compass direction, i.e. south is most efficient, while west is approximately equal to east and southwest is approximately equal to southeast. Complex systems of periods and tiers increase the ROI differences between large and small systems and may create asymmetry due to compass direction.

7. For net metering with multiple periods the payback rate by compass direction is dependent on the rate of electricity for the associated time of day. System economy improves when advantageous pricing matches peak panel production for the compass direction. The results of highly complex metering arrangements involving multiple periods and tiers is difficult to predict without sophisticated computer simulation.

The presence of multiple parameters with strong relationships to financial performance can complicate ROI prediction without the benefit of computer simulation, especially when parameters counteract each other. For instance, PV systems in Boston (with only a moderate resource) still provide simple paybacks better than Tampa (which has a better solar resource) due to Boston's relatively high electricity prices and the net metering arrangement which allows the bulk of site-generated electricity to be valued at retail. Phoenix, AZ, by contrast, has an excellent solar resource but systems there are burdened by a separate grid access charge and a net billing arrangement that pays substantially less for electricity generated during most seasons and time frames, effectively disincentivizing larger systems that produce excess electricity that cannot be used onsite. Seattle's generous net metering arrangement can't overcome the combined effects of extremely low-priced local electricity and a poor solar resource. The modest local electricity cost and extremely low $0.024 sell rate for electricity in Kansas is also a challenging hurdle to overcome.

The following summaries for each location show critical simulation inputs and conditions for two roof slopes and five compass directions, using the actual metering arrangement offered by the predominant utility in each area for both a 3 kW system and a 10 kW system. The summaries also include three ROI metrics for each size: Normalized Simple Payback (Simple Payback over the life of the system per the definition in the SAM simulation tool), NPV, and Simple Payback (investment cost/first year savings). The Appendices contain detailed results for the full range of system sizing, design parameters and cost inputs for all locations.

Summary Results – Phoenix, AZ

PHOENIX, ARIZONA NET BILLING – SAM INPUTS

ARIZONA PUBLIC SERVICE CO. (APS), Fixed Monthly Charge: $12.81[15]; + on-site distributed generation charge of $0.93 per kW_{DC} of nameplate capacity (grid access charge); System Cost: $3.17/W, $4.39/W

Period	Tier	Max. Usage, kWh	Buy Rate, $/kWh	Sell Rate, $/kWh[16]
1	1	Unlimited	0.119268238	0.02831
2	1	Unlimited	0.119268238	0.02897
3	1	Unlimited	0.254071768	0.03040
4	1	Unlimited	0.267845052	0.02989
5	1	Unlimited	0.034450896	0.02831

Weekday Periods

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
May	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Jun	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	2	2	2	2
Nov	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1

Weekend Periods

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jun	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Phoenix, AZ	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot Annual Load
Load (kWh)	1180	1025	950	1118	1273	1882	2174	1956	1677	1292	944	1000	16471

CITY, STATE	LATITUDE	GHI (kWh/m²/day)
Phoenix, AZ	33.4484° N	5.79

Roof Slope	Degrees
6/12	26.57
9/12	36.37

APS credits the excess energy per the most current rate rider (EPR-2) for each simulation step (hourly) over the month. The 'buy rate' includes taxes, fees and various utility adjustments including for renewable energy, environmental improvement surcharge, lost fixed cost recovery mechanism, and more.

Among the locations studied, Phoenix has…

- Excellent solar resource
- An additional grid access charge of $0.93/mo/$kW_{DC}$
- The least advantageous utility arrangement – net billing
- Very low sell rates
- P5 rates incentivize midday winter prod; P3 & P4 rates disincentivize late afternoon use and production

[15] https://www.aps.com/en/Residential/Service-Plans/Compare-Service-Plans

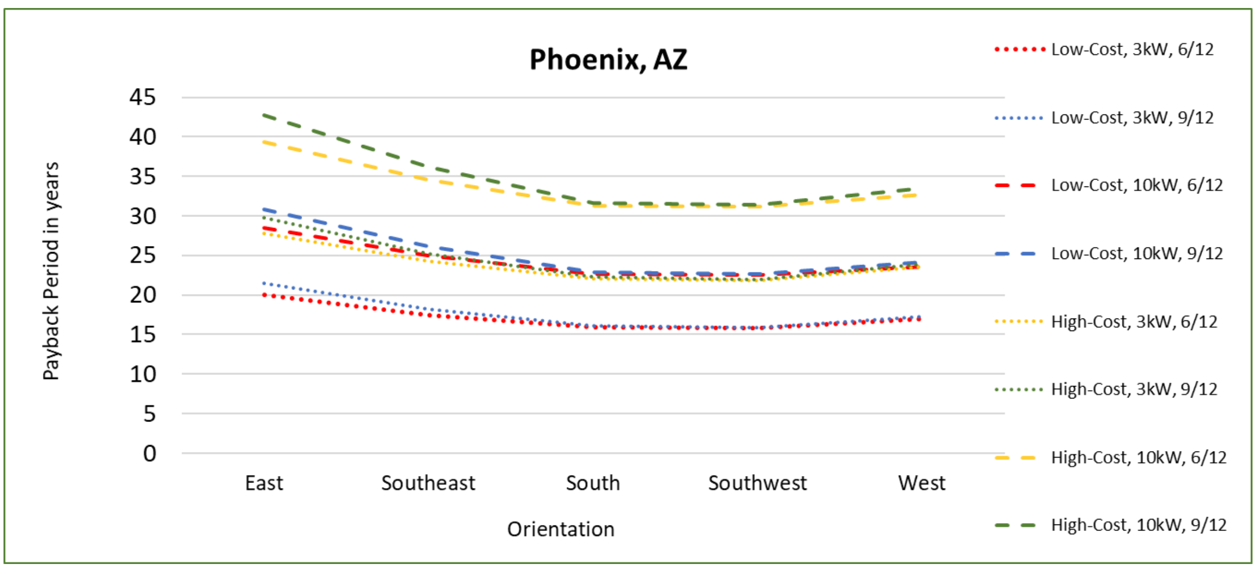
[16] https://www.aps.com/en/Utility/Regulatory-and-Legal/Rates-Schedules-and-Adjustors

PHOENIX, ARIZONA NET BILLING – ROI FOR DIFFERENT SYSTEM COSTS

System Size, kW	Array Tilt, Pitch	Array Azimuth	Energy Produced, kWh, Year 1	Value of Energy, $, Year 1	Results: Low End Cost ($3.17/Watt) Normalized Payback Period, years	Low End Cost ($3.17/Watt) Net Present Value, $	Low End Cost ($3.17/Watt) Simple Payback Period, Years	High End Cost ($4.39/Watt) Normalized Payback Period, years	High End Cost ($4.39/Watt) Net Present Value	High End Cost ($4.39/Watt) Simple Payback Period, Years
3	6/12	East	4410	$474	23.4	-1391	20.1	*	-3767	27.8
		Southeast	4986	$543	20.0	-533	17.5	27.3	-2909	24.2
		South	5092	$598	17.9	140	15.9	24.5	-2236	22.0
		Southwest	4705	$603	17.8	186	15.8	24.4	-2190	21.9
		West	4048	$559	19.4	-355	17.0	26.6	-2731	23.5
	9/12	East	4276	$443	25.4	-1767	21.5	*	-4143	29.8
		Southeast	4983	$523	20.9	-784	18.2	28.5	-3160	25.2
		South	5105	$591	18.2	56	16.1	24.8	-2320	22.3
		Southwest	4632	$600	17.9	160	15.8	24.5	-2216	21.9
		West	3835	$551	19.8	-459	17.3	27.0	-2835	23.9
10	6/12	East	14700	$1,115	*	-10126	28.4	*	-18046	39.4
		Southeast	16621	$1,269	29.5	-8182	25.0	*	-16101	34.6
		South	16974	$1,401	26.2	-6496	22.6	*	-14416	31.3
		Southwest	15683	$1,409	25.9	-6366	22.5	*	-14285	31.2
		West	13493	$1,342	27.4	-7204	23.6	*	-15123	32.7
	9/12	East	14252	$1,027	*	-11243	30.9	*	-19163	42.8
		Southeast	16610	$1,213	*	-8900	26.1	*	-16819	36.2
		South	17016	$1,387	26.5	-6683	22.9	*	-14602	31.7
		Southwest	15440	$1,397	26.2	-6525	22.7	*	-14445	31.4
		West	12785	$1,309	28.2	-7614	24.2	*	-15534	33.5

*Payback period exceeds analysis period

Simple Payback in Years (low cost: $3.17/Watt, high cost: $4.39/Watt)



Summary Results – Tampa, FL

TAMPA, FLORIDA NET METERING– SAM INPUTS

TAMPA ELECTRIC COMPANY (TECO) – Fixed Monthly Charge: $15.12 [17]**;** System Cost: $3.15/W, $4.36/W

Period	Tier	Max. Usage, kWh (per month)	Electricity Rate ($/kWh)
1	1	1000	0.10294
1	2	Unlimited	0.12692

Weekday Periods and Weekend Periods (same)

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Tampa, FL	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot Annual Load
Load (kWh)	1162	1054	987	1071	1228	1350	1403	1385	1312	1277	963	1080	14273

CITY, STATE	LATITUDE	GHI (kWh/m²/day)
Tampa, FL	27.9506° N	5.22

Roof Slope	Degrees
6/12	26.57
9/12	36.37

The 'buy rate' includes various adjustments and the added 19.88% tax includes municipality public service tax, Florida gross receipts tax and franchise fee. TECO credits the excess energy in kWh at the end of each billing cycle (monthly). There is no set 'sell rate' and SAM's 'Net Metering' is the closest scheme for this kind of arrangement, though it does convert net annual excess at the end of the year to dollars.

Among the locations studied, Tampa has…

- A very good solar resource
- Second-lowest real energy cost among studied locations
- Most generous utility terms (net metering in kWh)
- A usage tier that penalizes over-sized systems above 1,000 kWh/mo with an additional 25% charge

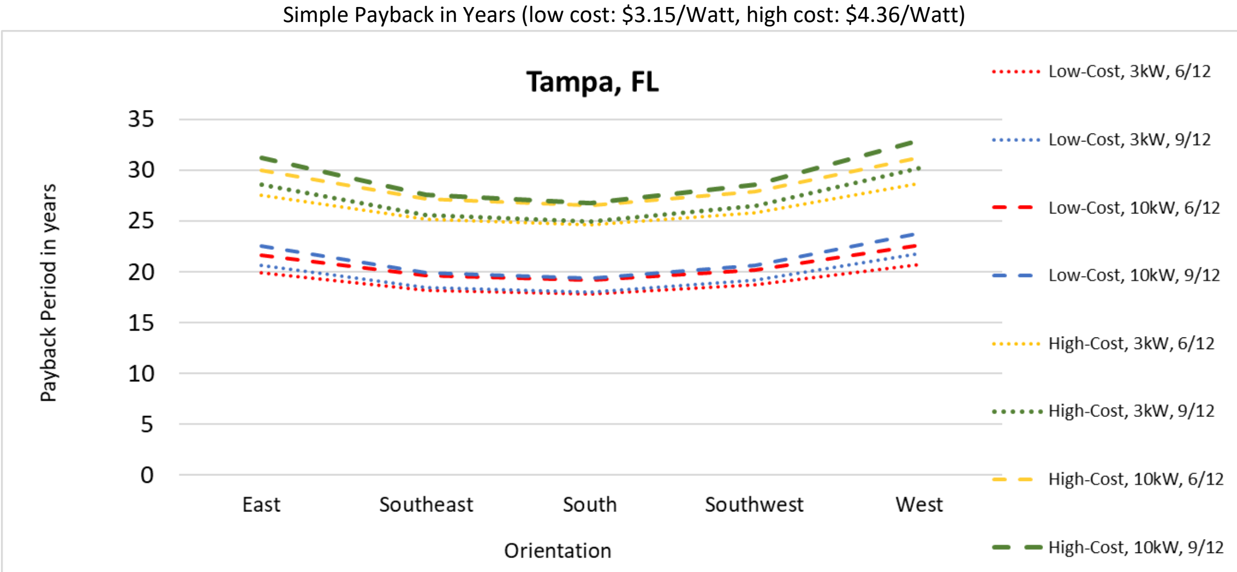
[17] https://www.tampaelectric.com/files/tariff/tariffsection6.pdf

TAMPA, FLORIDA NET METERING – ROI FOR DIFFERENT SYSTEM COSTS

System Size, kW	Array Tilt, Pitch	Array Azimuth	Energy Produced, kWh, Year 1	Value of Energy, $, Year 1	Results: Low End Cost ($3.15/Watt) Normalized Payback Period, years	Low End Cost ($3.15/Watt) Net Present Value	Low End Cost ($3.15/Watt) Simple Payback Period, Years	High End Cost ($4.36/Watt) Normalized Payback Period, years	High End Cost ($4.36/Watt) Net Present Value, $	High End Cost ($4.36/Watt) Simple Payback Period, Years
3	6/12	East	4074	$475	24.8	-1789	19.9	*	-4481	27.6
		Southeast	4513	$520	22.2	-1236	18.2	*	-3928	25.2
		South	4633	$532	21.6	-1093	17.8	*	-3785	24.6
		Southwest	4388	$506	23.0	-1408	18.7	*	-4100	25.9
		West	3901	$455	26.2	-2031	20.7	*	-4723	28.7
	9/12	East	3912	$457	26.0	-2005	20.7	*	-4696	28.6
		Southeast	4445	$512	22.6	-1332	18.5	*	-4024	25.5
		South	4585	$525	22.0	-1174	18.0	*	-3865	24.9
		Southwest	4286	$494	23.7	-1558	19.1	*	-4250	26.5
		West	3696	$433	28.0	-2315	21.8	*	-5007	30.2
10	6/12	East	13579	$1,454	27.7	-7581	21.7	*	-16553	30.0
		Southeast	15043	$1,604	24.5	-5736	19.6	*	-14708	27.2
		South	15443	$1,645	23.7	-5231	19.1	*	-14203	26.5
		Southwest	14627	$1,561	25.3	-6259	20.2	*	-15231	27.9
		West	13005	$1,394	29.2	-8305	22.6	*	-17277	31.3
	9/12	East	13039	$1,398	29.1	-8262	22.5	*	-17234	31.2
		Southeast	14816	$1,581	24.9	-6021	19.9	*	-14993	27.6
		South	15284	$1,629	24.0	-5431	19.3	*	-14403	26.8
		Southwest	14285	$1,526	26.1	-6691	20.6	*	-15663	28.6
		West	12320	$1,324	*	-9168	23.8	*	-18140	32.9

*Payback period exceeds analysis period

Simple Payback in Years (low cost: $3.15/Watt, high cost: $4.36/Watt)



Summary Results – Boston, MA

BOSTON, MASSACHUSETTS NET METERING– SAM INPUTS

EVERSOURCE, Fixed Monthly Charge $7.00[18] **;** System Cost: $3.27/W, $4.53/W

Boston, MA Net Metering

Period	Tier	Max. Usage, kWh (per month)	Electricity Rate [19] ($/kWh)	Credit Rate [20] ($/kWh)
1	1	Unlimited	0.22273	0.20609
2	1	Unlimited	0.19633	0.17969

Weekday Periods and Weekend Periods (same)

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Nov	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dec	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Boston MA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot Annual Load
Load (kWh)	3819	3564	3099	2307	1448	1074	1098	967	1034	1587	2554	3270	25820

CITY, STATE	LATITUDE	GHI (kWh/m²/day)
Boston, MA	42.3601° N	4.06

Roof Slope	Degrees
6/12	26.57
9/12	36.37

Eversource credits the monthly excess kWh energy as $ credit to the customer in the same billing period. (SAM's Net Metering with $ Credits is the closest scheme for this kind of arrangement, even though it credits the customer in the following month). The 'buy rate' for residential space heating (A4 - due to the simulation choice of an all-electric home) is selected and adjusted for taxes. The 'sell rate' is obtained by deducting the adjustments and fees from buy rate and does not include taxes.

Among the locations studied, Boston has…

- A moderate solar resource
- The highest real energy cost
- The 2nd most generous utility terms (net metering with monthly excess converted to dollar value and credited to the customer)

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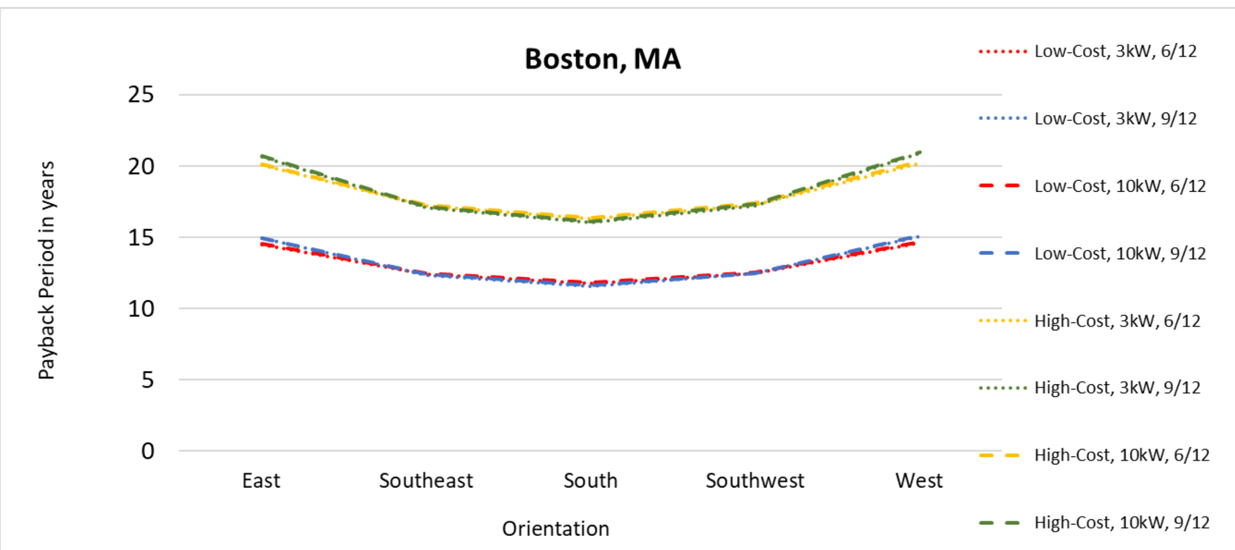
[18] https://www.eversource.com/content/ema-c/residential/my-account/billing-payments/about-your-bill/rates-tariffs/basic-service
[19] https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_38
[20] https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_38

BOSTON, MASSACHUSETTS NET METERING – ROI FOR DIFFERENT SYSTEM COSTS

System Size, kW	Array Tilt, Pitch	Array Azimuth	Energy Produced, kWh, Year 1	Value of Energy, $, Year 1	Results: Low End Cost ($3.27/Watt) Normalized Payback Period, years	Low End Cost ($3.27/Watt) Net Present Value	Low End Cost ($3.27/Watt) Simple Payback Period, Years	High End Cost ($4.53/Watt) Normalized Payback Period, years	High End Cost ($4.53/Watt) Net Present Value	High End Cost ($4.53/Watt) Simple Payback Period, Years
3	6/12	East	3225	$678	16.2	1002	14.5	22.6	-1575	20.0
		Southeast	3765	$791	13.7	2382	12.4	19.1	-196	17.2
		South	3971	$834	12.9	2908	11.8	18.0	331	16.3
		Southwest	3740	$786	13.8	2318	12.5	19.2	-260	17.3
		West	3196	$672	16.4	926	14.6	22.8	-1651	20.2
	9/12	East	3127	$658	16.8	751	14.9	23.4	-1826	20.7
		Southeast	3788	$796	13.6	2441	12.3	19.0	-137	17.1
		South	4039	$848	12.7	3079	11.6	17.7	502	16.0
		Southwest	3753	$789	13.8	2351	12.4	19.2	-227	17.2
		West	3092	$650	17.0	659	15.1	23.7	-1918	20.9
10	6/12	East	10750	$2,252	16.3	3255	14.5	22.7	-5336	20.1
		Southeast	12548	$2,623	13.8	7810	12.5	19.2	-782	17.3
		South	13237	$2,764	13.0	9542	11.8	18.1	951	16.4
		Southwest	12467	$2,605	13.9	7589	12.6	19.3	-1003	17.4
		West	10653	$2,230	16.4	2991	14.7	22.9	-5600	20.3
	9/12	East	10423	$2,187	16.8	2455	15.0	23.4	-6136	20.7
		Southeast	12626	$2,642	13.7	8036	12.4	19.0	-555	17.1
		South	13463	$2,813	12.8	10143	11.6	17.8	1551	16.1
		Southwest	12511	$2,616	13.8	7728	12.5	19.2	-863	17.3
		West	10305	$2,161	17.0	2137	15.1	23.7	-6455	21.0

*Payback period exceeds analysis period

Simple Payback in Years (low cost: $3.27/Watt, high cost: $4.53/Watt)



Summary Results – Kansas City, MO

KANSAS CITY, MISSOURI NET METERING– SAM INPUTS

KANSAS CITY POWER AND LIGHTS (KCP&L) – Fixed Monthly Charge: $11.47; System Cost: $3.22/W, $4.46/W

Period	Tier	Max. Usage, kWh (per month)	Buy Rate[21] ($/kWh)	Sell Rate ($/kWh)
1	1	Unlimited	0.157135	0.024
2	1	1000	0.11200	0.024
2	2	Unlimited	0.07457	0.024

Weekday Periods and Weekend Periods (same)

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Feb	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mar	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Apr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
May	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Nov	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dec	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Kansas City, MO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot Annual Load
Load (kWh)	3853	3196	2424	1487	1314	1471	1807	1495	1199	1471	1356	3105	24178

CITY, STATE	LATITUDE	GHI (kWh/m²/day)
Kansas City, MO	39.0997° N	4.38

Roof Slope	Degrees
6/12	26.57
9/12	36.37

KCPL credits the billing period excess energy at a sell rate determined in the agreement. The 'buy rate' includes various adjustments and delivery charges as well as taxes and fees.

Among the locations studied, Kansas City has…

- A moderate solar resource
- Moderate real energy cost
- Lowest sell rate for site-generated electricity
- The 2nd most generous utility agreement (net metering with monthly excess converted to dollar value and credited to the customer)

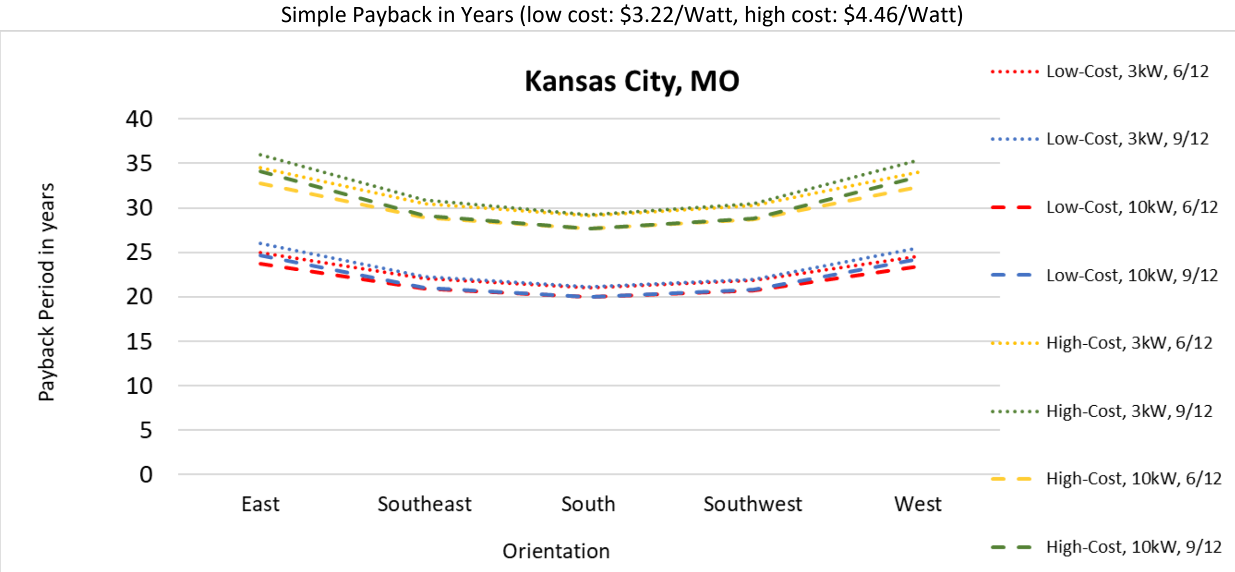
[21] https://www.evergy.com/-/media/documents/billing/missouri/detailed_tariffs_mo/residential-service-081419.pdf?la=en

KANSAS CITY, MISSOURI NET METERING – ROI FOR DIFFERENT SYSTEM COSTS

System Size, kW	Array Tilt, Pitch	Array Azimuth	Energy Produced, kWh, Year 1	Value of Energy, $, Year 1	Results: Low End Cost ($3.22/Watt) Normalized Payback Period, years	Low End Cost Net Present Value	Low End Cost Simple Payback Period, Years	High End Cost ($4.46/Watt) Normalized Payback Period, years	High End Cost Net Present Value	High End Cost Simple Payback Period, Years
3	6/12	East	3487	$388	*	-2827	24.9	*	-5503	34.5
		Southeast	4050	$438	28.3	-2204	22.0	*	-4879	30.5
		South	4286	$459	26.7	-1949	21.0	*	-4624	29.1
		Southwest	4076	$443	28.0	-2152	21.8	*	-4827	30.2
		West	3517	$393	*	-2761	24.6	*	-5437	34.1
	9/12	East	3359	$372	*	-3023	26.0	*	-5699	36.0
		Southeast	4047	$433	28.7	-2264	22.3	*	-4940	30.9
		South	4332	$458	26.8	-1968	21.1	*	-4643	29.2
		Southwest	4081	$439	28.3	-2197	22.0	*	-4873	30.5
		West	3398	$378	*	-2941	25.5	*	-5616	35.4
10	6/12	East	11623	$1,360	*	-8571	23.7	*	-17490	32.8
		Southeast	13502	$1,541	26.3	-6277	20.9	*	-15197	28.9
		South	14286	$1,610	24.8	-5389	20.0	*	-14308	27.7
		Southwest	13588	$1,554	26.0	-6108	20.7	*	-15027	28.7
		West	11725	$1,378	*	-8347	23.4	*	-17266	32.4
	9/12	East	11196	$1,307	*	-9248	24.6	*	-18167	34.1
		Southeast	13491	$1,531	26.6	-6423	21.0	*	-15342	29.1
		South	14439	$1,614	24.8	-5374	20.0	*	-14293	27.6
		Southwest	13604	$1,548	26.2	-6204	20.8	*	-15123	28.8
		West	11326	$1,330	*	-8969	24.2	*	-17889	33.5

*Payback period exceeds analysis period

Simple Payback in Years (low cost: $3.22/Watt, high cost: $4.46/Watt)



Summary Results – Seattle, WA

SEATTLE, WASHINGTON NET METERING– SAM INPUTS

PUGET SOUND ENERGY, Fixed Monthly Charge $7.99 [22]; System Cost: $3.23/W, $4.47/W

Period	Tier	Max. Usage, kWh (per month)	Buy Rate ($/kWh)
1	1	600	$0.087
1	2	Unlimited	$0.107

Weekday Periods and Weekend Periods (same)

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Seattle, WA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot Annual Load
Load (kWh)	2638	2286	1926	1624	1359	1185	1218	1135	1110	1595	2021	2419	20515

CITY, STATE	LATITUDE	GHI (kWh/m²/day)
Seattle, WA	47.6062° N	3.47

Roof Slope	Degrees
6/12	26.57
9/12	36.37

Puget Sound Energy credits the excess energy in kWh. The 'buy rate' has been adjusted for 3.60% tax increase and there is no 'sell rate'. SAM's Net Metering is the closest modeling method for this kind of arrangement.

Among the locations studied, Seattle has…

- Poor solar resource
- Lowest real energy cost
- Most generous utility terms (net metering in kWh)

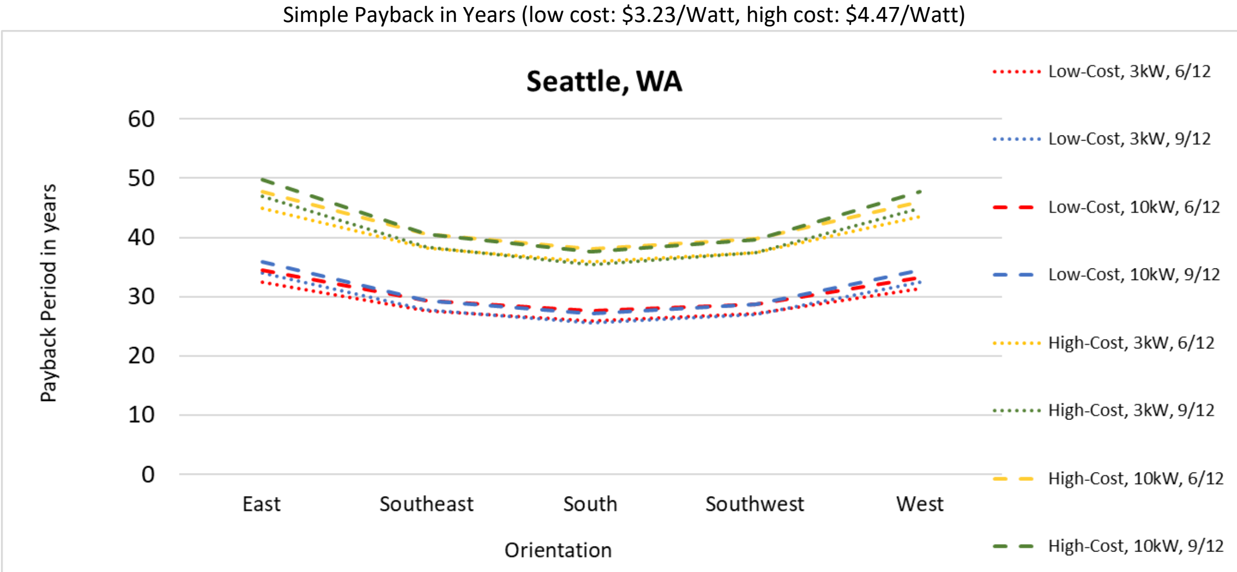
[22] https://www.pse.com/pages/rates/electric-tariffs-and-rules#sort=%40fdocumentdate43883%20descending

SEATTLE, WASHINGTON NET METERING – ROI FOR DIFFERENT SYSTEM COSTS

System Size, kW	Array Tilt, Pitch	Array Azimuth	Energy Produced, kWh, Year 1	Value of Energy, $, Year 1	Results: Low End Cost ($3.23/Watt) Normalized Payback Period, years	Low End Cost ($3.23/Watt) Net Present Value	Low End Cost ($3.23/Watt) Simple Payback Period, Years	High End Cost ($4.47/Watt) Normalized Payback Period, years	High End Cost ($4.47/Watt) Net Present Value	High End Cost ($4.47/Watt) Simple Payback Period, Years
3	6/12	East	2785	$298	*	-3464	32.5	*	-5958	45.0
		Southeast	3272	$350	*	-2824	27.6	*	-5319	38.3
		South	3491	$374	29.8	-2537	25.9	*	-5032	35.9
		Southwest	3340	$358	*	-2735	27.1	*	-5230	37.5
		West	2881	$309	*	-3337	31.4	*	-5831	43.5
	9/12	East	2665	$285	*	-3621	34.0	*	-6115	47.0
		Southeast	3264	$350	*	-2835	27.7	*	-5330	38.4
		South	3533	$378	29.4	-2482	25.6	*	-4977	35.4
		Southwest	3349	$359	*	-2723	27.0	*	-5218	37.4
		West	2784	$298	*	-3464	32.5	*	-5959	45.0
10	6/12	East	9282	$938	*	-12213	34.4	*	-20529	47.7
		Southeast	10908	$1,103	*	-10180	29.3	*	-18496	40.5
		South	11636	$1,173	*	-9300	27.5	*	-17616	38.1
		Southwest	11133	$1,123	*	-9924	28.8	*	-18239	39.8
		West	9604	$971	*	-11828	33.3	*	-20144	46.0
	9/12	East	8883	$900	*	-12666	35.9	*	-20982	49.7
		Southeast	10880	$1,103	*	-10187	29.3	*	-18502	40.5
		South	11776	$1,190	*	-9095	27.1	*	-17411	37.6
		Southwest	11164	$1,128	*	-9861	28.6	*	-18177	39.6
		West	9280	$938	*	-12216	34.4	*	-20531	47.7

*Payback period exceeds analysis period

Simple Payback in Years (low cost: $3.23/Watt, high cost: $4.47/Watt)



CONCLUSIONS

Prediction of cost-effectiveness or return on investment (ROI) for residential onsite PV systems is impacted by a broad range of location- and project-specific input data. The complex interactions of these numerous parameters make it difficult to predict a precise outcome without detailed computer simulation. However, it's possible to identify the best and worst opportunities in a specific location.

Local energy rates are a driving component. Higher local electricity pricing means the savings due to usage avoidance through site-generation are commensurately higher (e.g. Boston). Where local power is cheap PV systems seldom pay for themselves at today's system prices (e.g. Seattle).

The buy/sell arrangement between the local utility and the electricity customer is especially important in the context of system size and monthly load profiles. When site-generated electricity is fed back into the transmission grid and the meter is allowed to "run backwards" the buy rate essentially equals the sell rate; the residential customer earns retail prices and saves all *per kWh* costs associated with energy usage, including taxes and fees. Net metering that credits excess energy as kWh on a net basis for each billing cycle carries that advantage forward. Typically, a dollar adjustment is made at the end of each billing year, sometimes at a lower price, but this is likely to be small due to seasonal balancing. With this arrangement the size of the system matters very little – all energy production earns the highest possible value. Over-sizing is detrimental whenever the arrangement gets more complex and conversion from energy units to dollars occurs. Energy production that directly offsets usage is much more valuable than excess energy that is subject to a monthly conversion factor – the customer's "sell rate" is often lower, and sometimes much lower, than the "buy rate." Net billing arrangements that calculate excess energy on a time-step basis and then convert to $ value are even less advantageous (and penalize oversized systems more.) The potential for wide variance between buy and sell rates – and how pricing periods and tiers relate to the pattern of solar electricity production at the site – add complexity and generally reduce cost effectiveness. These considerations call for careful system sizing with respect the building's electricity load (usage). The mechanical systems for the houses in this study were all-electric. Houses which use gas for heating, cooking and water heating will have smaller electric loads, and – under utility arrangements where excess site-generation earns less than retail electricity rates – oversized systems will have worse paybacks than properly sized systems.

A primary factor is the site's available solar resource due to the location's latitude and atmospheric conditions – a situation over which the builder has no control. In this study, Arizona and Florida provided the best irradiance, Seattle the poorest. The builder does control physical design choices like roof size, azimuth (the compass direction the PV array faces) and tilt (the angle of the panels – conventionally parallel to the roof angle). Given traditional neighborhood layouts, floorplans that are always perpendicular to the street do not optimize azimuth, and therefore undermine the ability to achieve maximum benefit for an entire development. No matter the location, arrays facing south, southeast, and southwest provide the best production. Tilts (roof pitches) have only a small impact.

Financial project parameters like first cost affect all ROI metrics; operational costs and the nominal discount rate have a strong influence on cash flow and therefore normalized simple payback and NPV.

This study examined the addition of a solar electricity generation system for new home construction where the PV system price is included in the sale price of the entire house. The investment cost of the system is one among many factors that drive cost effectiveness. Additional factors include energy pricing and net metering arrangements, system sizing, solar resource, investment financial parameters, system performance and other design choices. The complex interrelationships between these many influences mean a reliable simulation tool and precise, accurate inputs are vital for determining whether a solar PV system is in the homeowner’s best interest.

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APPENDIX A:
BASELINE BUILDING CHARACTERISTICS

The chosen baseline building represents a medium-sized house with 2,352 s.f. of above-grade conditioned floor area, three bedrooms and four occupants. There are two roof slopes used in the analysis in this report. For each slope, the area is calculated for the longest side.

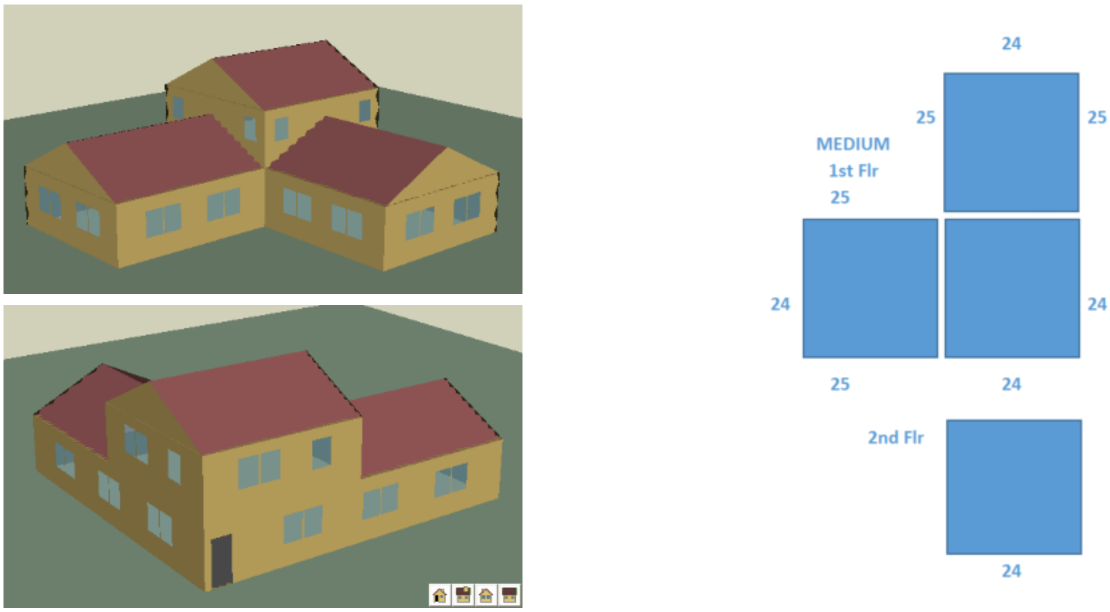

Figure 3. 3-D View (left) and Geometries (right) of the Baseline Building

Table 13. Area Available for Solar Panel

Roof slope	9/12	6/12
Width of the roof (L.F.)	15.00	13.42
Length of the roof (L.F.)	50.00	50.00
Area of the roof	750	671
Safety Factor (12% of required area)	90	81
Area available for solar panels	660	590

The baseline house selected for the modeling was assumed to have following parameters:

Table 14. Incidence of Building Characteristics per Climate Zone

City	Climate Zone	Foundation	Wall
Phoenix, AZ	2B	Slab	Frame
Tampa, FL	2A	Slab	Frame
Boston, MA	5A	Basement	Frame
Kansas City, MO	4A	Basement	Frame
Seattle, WA	4C	Basement	Frame

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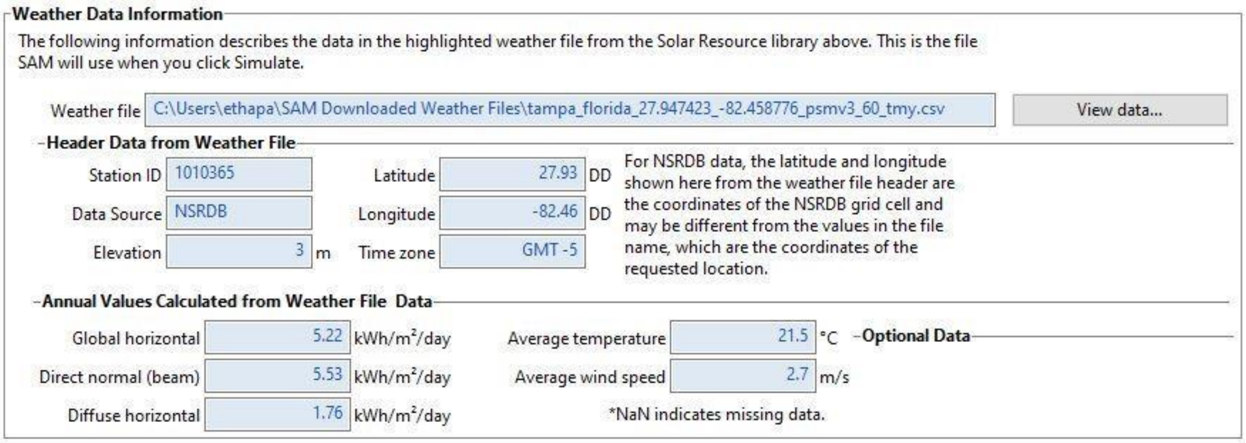
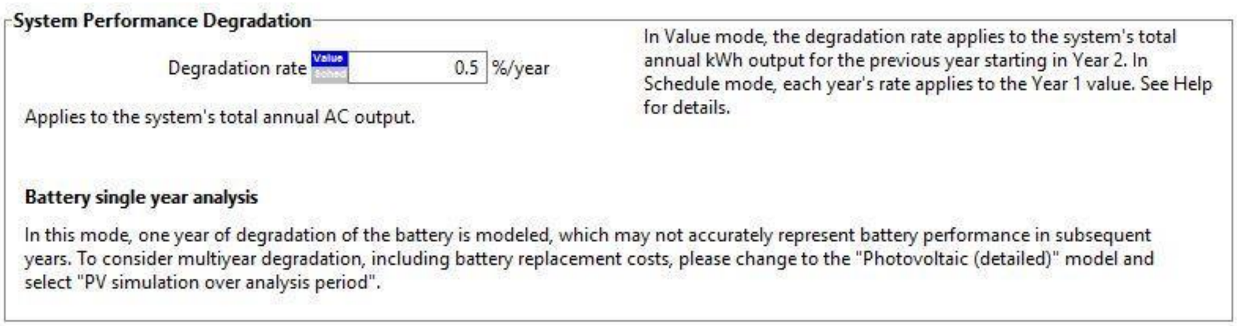
APPENDIX B:
SIMULATION INPUTS

Examples of SAM modeling inputs are shown here. This sample configuration is for Tampa, Florida:

1) **Location and Resources:** The Location and Resource page provides access to weather files for various locations and reports geographic and solar data.

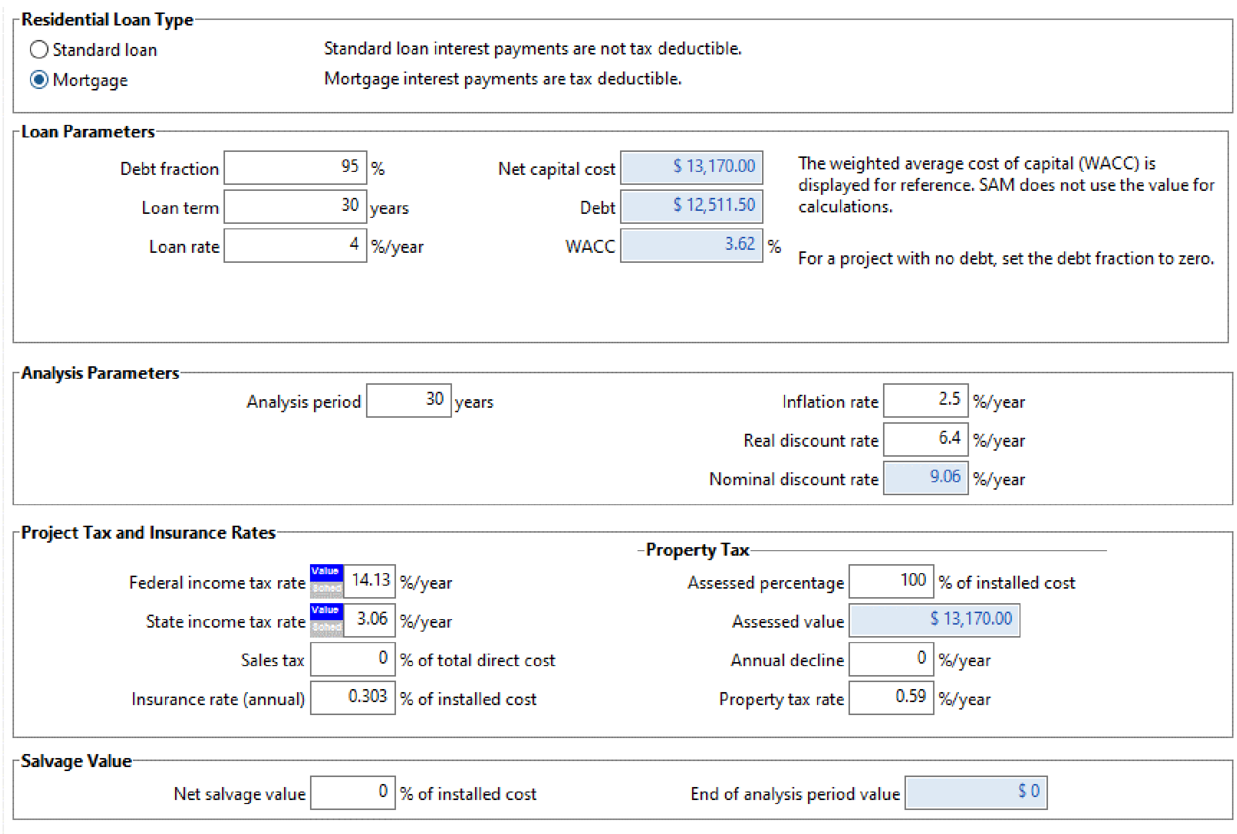


2) **Lifetime:** An annual degradation rate of 0.5% was assumed for all configurations.

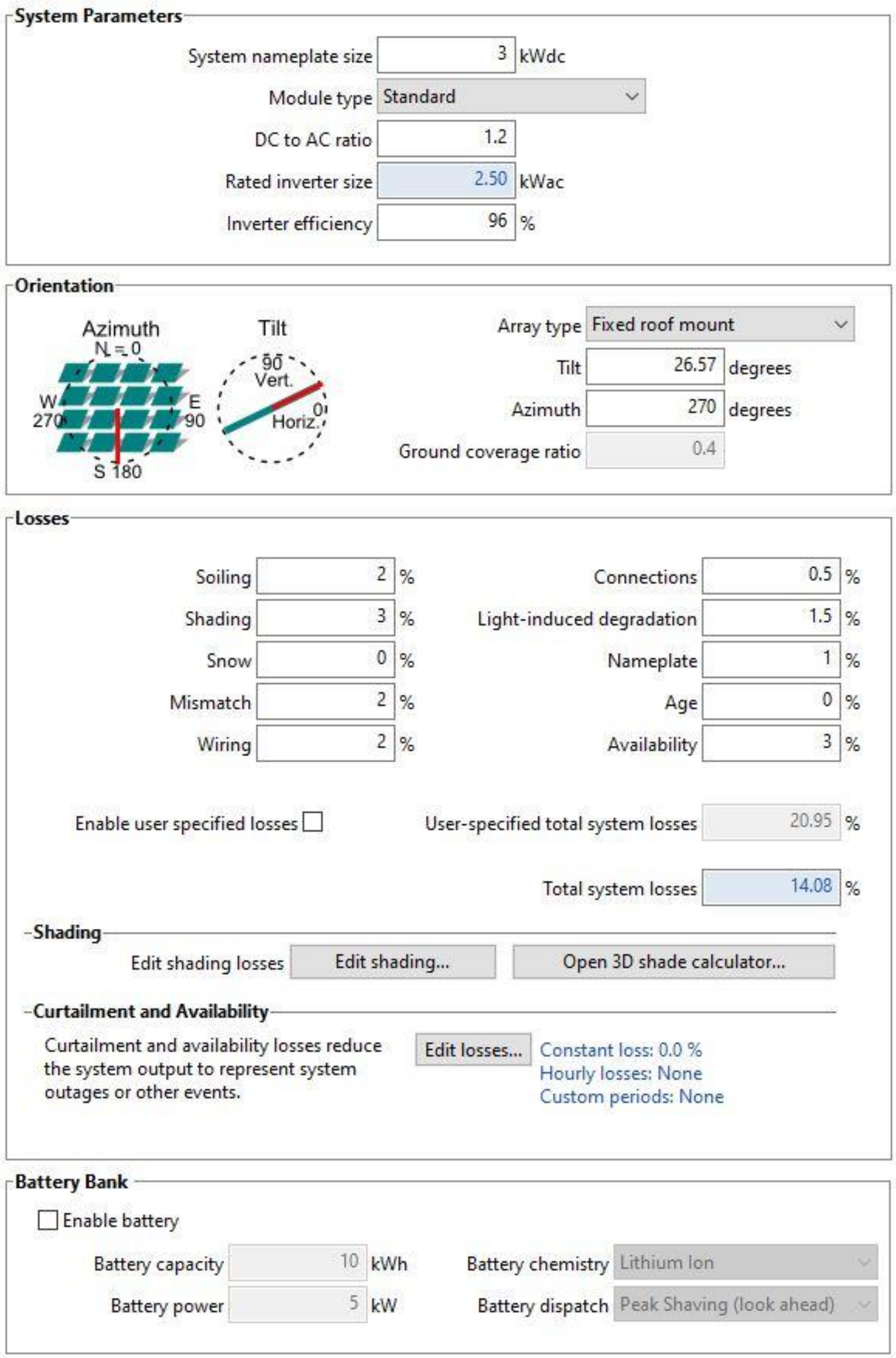


3) **Incentives:** Incentives were not included in this analysis.

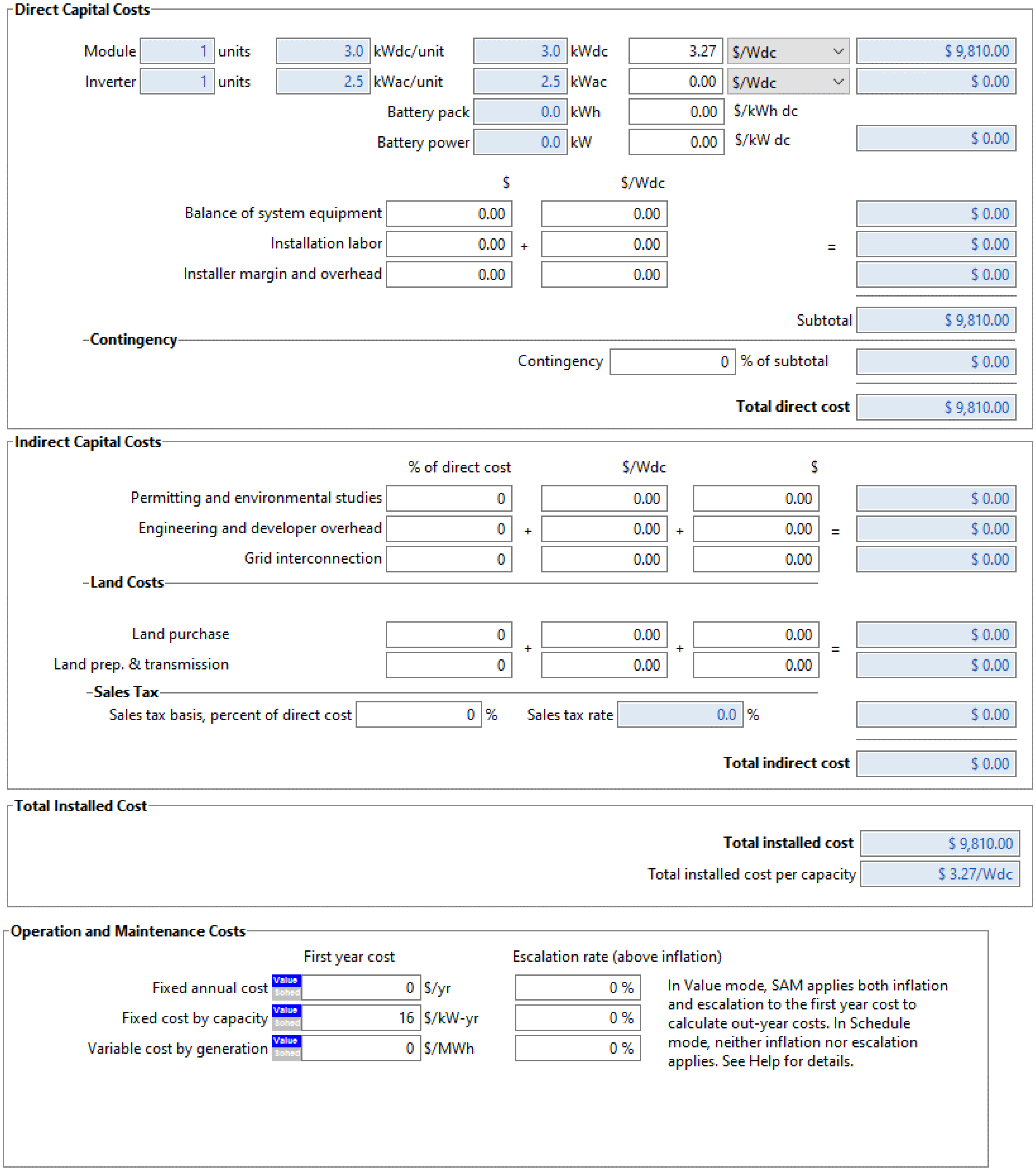
4) **Financial Parameters:** The analysis period was set to 30 years. A debt fraction of 95% and a loan term of 30 years with a loan rate 4% was used. Appropriate financial parameters for state and local taxes, property insurance and tax, were used as input for each location analyzed. These costs apply only to the "Normalized" Payback Rate and the NPV. Components of the system were estimated to have no salvage value at the end of the 30-year analysis period, coincident with the final payment of the assumed 30-year mortgage. As a capital expense, sales tax included in total soft costs as described in the narrative and input into the SAM simulation under "Direct Capital Costs." As an operational cost, sales tax is included in the total electricity rate ($/kW) input under "Electric Rates."



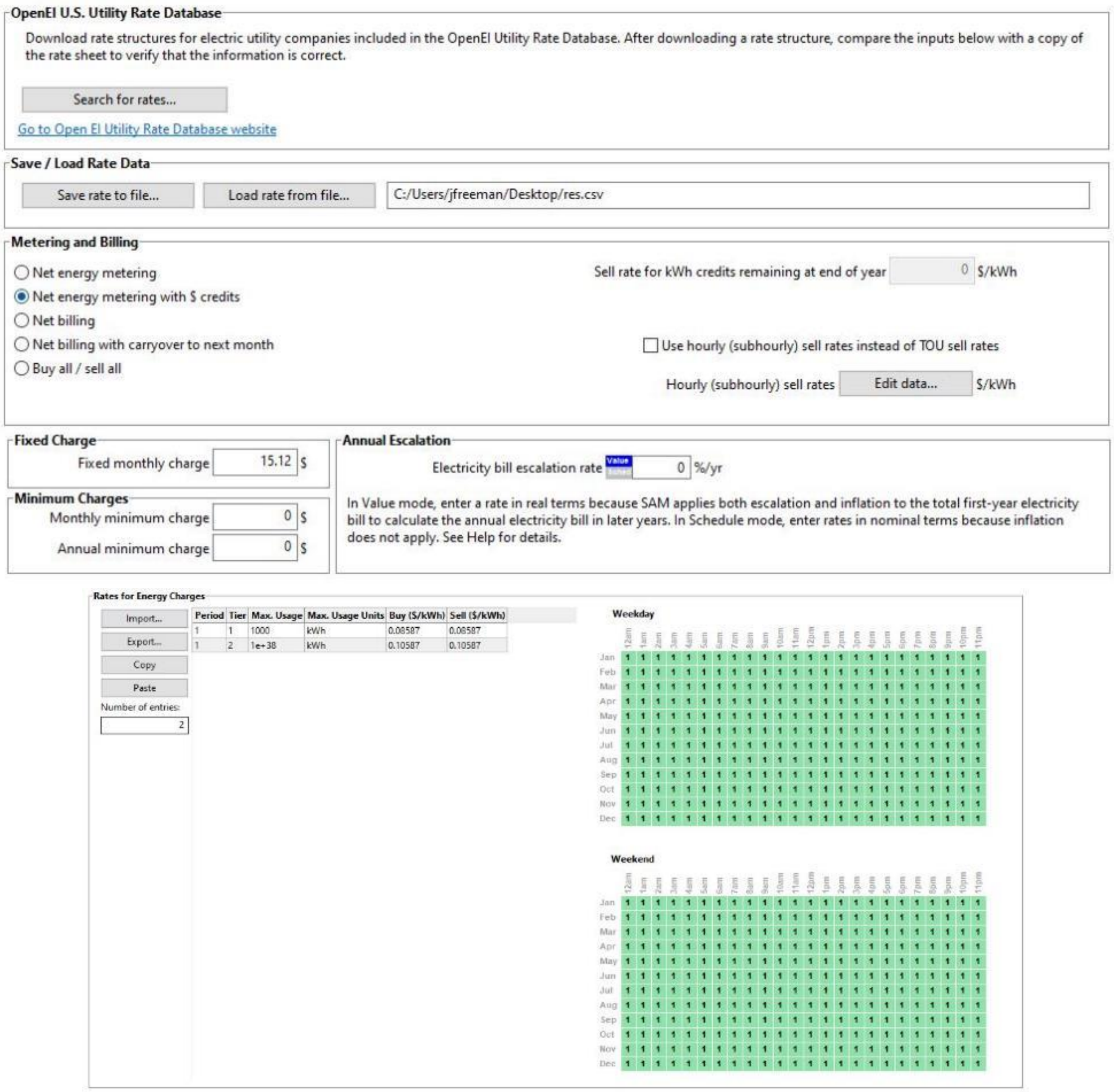
5) **System Design:** The range of System Design variables simulated for each location include system capacity (3 kW to 2 kW), Tilt (parallel with roof slope) and Azimuth (compass direction). SAM's default values were accepted for other inputs.



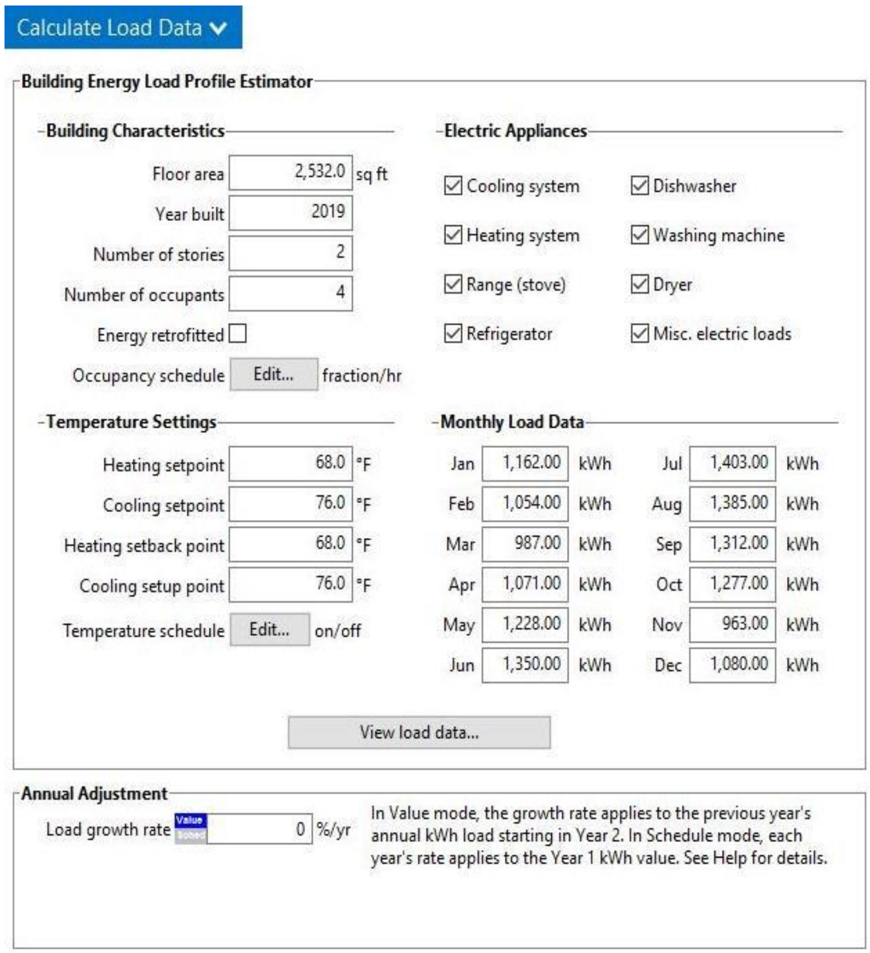
6) System Cost: Total installed cost per capacity includes all hard and softs costs, adjusted for location and discussed in detail in the report. Sales tax is included in total soft costs as described in the narrative and entered into Direct Capital Costs.



7) **Electric Rates:** Predominant utility companies were selected for each location and metering arrangements were taken directly from their websites, including fixed charges and electricity buy and sell rates by schedule and quantity. For net metering arrangements, region-specific sales tax (%) is applied to electricity charges from the utility and included in the reported $/kWh to account for production that offsets actual usage. In the case where a residential PV system generates more energy than is used (a “net producer”), this calculation would be incorrect, since tax would not be calculated against a credit. No systems in this analysis met this condition. For net billing arrangements, the sell rate includes sales taxes but the buy rate does not.



8) **Electric Load:** The values for reference building physical characteristics are constant for all locations, but each is adjusted to meet local energy code by climate zone. Houses in all locations are modeled as all-electric. Heating and cooling setpoints and setbacks are constant for all locations. Monthly load data is specific to each location and was determined using energy modeling.



APPENDIX C:
EXAMPLE CASH FLOW - PHOENIX, AZ

An example cash flow for a single simulation with following parameters is shown in table 11.

Location:	Phoenix, AZ
System size:	3kW
Tilt	6/12
Azimuth:	90 degrees
System Cost:	3.17 $/Watt
Billing Arrangement:	Net Billing

Table 15. Example Cash Flow for a Single Simulation, Phoenix, Arizona

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PRODUCTION																
Energy (kWh)	0	5092	5067	5041	5016	4991	4966	4941	4917	4892	4867	4843	4819	4795	4771	4747
SAVINGS																
Value of electricity savings ($)	0	598	611	623	636	649	662	675	689	703	717	732	747	762	778	793
OPERATING EXPENSES																
O&M fixed expense ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M production-based expense ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M capacity-based expense ($)	0	81	84	86	88	90	92	94	97	99	102	104	107	110	112	115
Property tax expense ($)	0	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Insurance expense ($)	0	29	30	30	31	32	33	33	34	35	36	37	38	39	40	41
Net salvage value ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total operating expense ($)	0	166	169	172	175	178	181	184	187	190	194	197	201	204	208	212
Deductible expenses ($)	0	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56
PROJECT DEBT																
Debt balance ($)	9035	8873	8706	8532	8350	8162	7966	7762	7550	7330	7100	6862	6614	6356	6088	5809
Interest payment ($)	0	361	355	348	341	334	326	319	310	302	293	284	274	265	254	244
Principal payment ($)	0	161	168	174	181	188	196	204	212	220	229	238	248	258	268	279
Total P&I debt payment ($)	0	522	522	522	522	522	522	522	522	522	522	522	522	522	522	522
DIRECT CASH INCENTIVES																
STATE INCOME TAX																
State taxable income less deductions ($)	0	-417	-411	-404	-397	-390	-383	-375	-367	-358	-349	-340	-331	-321	-310	-300
State PTC ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
State ITC ($)		0														
State tax savings ($)	0	13	13	12	12	12	12	11	11	11	11	10	10	10	9	9
FEDERAL INCOME TAX																
Federal taxable income less deductions ($)	0	-405	-398	-392	-385	-378	-371	-363	-355	-347	-339	-330	-320	-311	-301	-290
Federal PTC ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Federal ITC ($)		0														
Federal tax savings ($)	0	57	56	55	54	53	52	51	50	49	48	47	45	44	43	41
After-tax annual costs ($)	-476	-619	-623	-627	-631	-635	-639	-644	-648	-653	-658	-663	-668	-673	-679	-684
After-tax cash flow ($)	-476	-20	-12	-4	5	14	23	32	41	50	60	69	79	89	99	109

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PRODUCTION															
Energy (kWh)	4723	4700	4676	4653	4629	4606	4583	4560	4538	4515	4492	4470	4448	4425	4403
SAVINGS															
Value of electricity savings ($)	810	826	843	860	877	895	913	932	951	970	990	1010	1030	1051	1072
OPERATING EXPENSES															
O&M fixed expense ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M production-based expense ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M capacity-based expense ($)	118	121	124	127	130	134	137	140	144	147	151	155	159	163	167
Property tax expense ($)	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Insurance expense ($)	42	43	44	45	46	47	48	50	51	52	53	55	56	58	59
Net salvage value ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total operating expense ($)	216	220	224	228	232	237	241	246	251	256	261	266	271	276	282
Deductible expenses ($)	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56
PROJECT DEBT															
Debt balance ($)	5519	5217	4903	4577	4238	3885	3518	3136	2739	2326	1896	1450	985	502	0
Interest payment ($)	232	221	209	196	183	170	155	141	125	110	93	76	58	39	20
Principal payment ($)	290	302	314	326	339	353	367	382	397	413	429	447	464	483	502
Total P&I debt payment ($)	522	522	522	522	522	522	522	522	522	522	522	522	522	522	522
DIRECT CASH INCENTIVES															
STATE INCOME TAX															
State taxable income less deductions ($)	-288	-277	-265	-252	-239	-226	-211	-197	-182	-166	-149	-132	-114	-96	-76
State PTC ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
State ITC ($)															
State tax savings ($)	9	8	8	8	7	7	6	6	6	5	5	4	3	3	2
FEDERAL INCOME TAX															
Federal taxable income less deductions ($)	-280	-268	-257	-245	-232	-219	-205	-191	-176	-161	-145	-128	-111	-93	-74
Federal PTC ($)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Federal ITC ($)															
Federal tax savings ($)	40	38	36	35	33	31	29	27	25	23	20	18	16	13	10
After-tax annual costs ($)	-690	-696	-702	-708	-715	-721	-728	-735	-743	-750	-758	-766	-774	-783	-792
After-tax cash flow ($)	120	130	141	152	163	174	185	196	208	220	232	244	256	268	281

APPENDIX G:
RESULTS FOR PHOENIX (NET BILLING)

ARIZONA PUBLIC SERVICE CO. (APS), Fixed Monthly Charge: $12.81 + on-site distributed generation charge of $0.93 per kW_{DC} of nameplate capacity (grid access charge);
Total Annual Load (kWh) = 16471
(* indicates no results due to payback period exceeding analysis period)

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.17/Watt)			High End Cost ($4.39/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
3	6/12	East	4410	$474	23.4	-1391	20.1	*	-3767	27.8
3	6/12	S East	4986	$543	20.0	-533	17.5	27.3	-2909	24.2
3	6/12	South	5092	$598	17.9	140	15.9	24.5	-2236	22.0
3	6/12	S West	4705	$603	17.8	186	15.8	24.4	-2190	21.9
3	6/12	West	4048	$559	19.4	-355	17.0	26.6	-2731	23.5
3	9/12	East	4276	$443	25.4	-1767	21.5	*	-4143	29.8
3	9/12	S East	4983	$523	20.9	-784	18.2	28.5	-3160	25.2
3	9/12	South	5105	$591	18.2	56	16.1	24.8	-2320	22.3
3	9/12	S West	4632	$600	17.9	160	15.8	24.5	-2216	21.9
3	9/12	West	3835	$551	19.8	-459	17.3	27.0	-2835	23.9
4	6/12	East	5880	$607	24.5	-2139	20.9	*	-5307	28.9
4	6/12	S East	6648	$697	20.8	-1027	18.2	28.4	-4195	25.2
4	6/12	South	6789	$769	18.6	-136	16.5	25.4	-3304	22.8
4	6/12	S West	6273	$778	18.4	-31	16.3	25.1	-3198	22.6
4	6/12	West	5397	$728	19.9	-665	17.4	27.2	-3833	24.1
4	9/12	East	5701	$562	26.7	-2677	22.5	*	-5845	31.2
4	9/12	S East	6644	$667	21.9	-1391	19.0	29.8	-4558	26.3
4	9/12	South	6806	$759	18.9	-263	16.7	25.8	-3430	23.1
4	9/12	S West	6176	$773	18.5	-91	16.4	25.3	-3259	22.7
4	9/12	West	5114	$716	20.3	-811	17.7	27.7	-3979	24.5
5	6/12	East	7350	$724	25.7	-3068	21.9	*	-7028	30.3
5	6/12	S East	8311	$830	21.9	-1753	19.1	29.8	-5713	26.4
5	6/12	South	8487	$918	19.6	-668	17.3	26.6	-4628	23.9
5	6/12	S West	7842	$930	19.3	-523	17.0	26.3	-4483	23.6
5	6/12	West	6747	$876	20.7	-1209	18.1	28.2	-5168	25.1
5	9/12	East	7126	$666	28.3	-3772	23.8	*	-7732	33.0
5	9/12	S East	8305	$792	23.1	-2218	20.0	*	-6178	27.7
5	9/12	South	8508	$904	19.9	-838	17.5	27.1	-4798	24.3
5	9/12	S West	7720	$921	19.5	-622	17.2	26.5	-4582	23.8
5	9/12	West	6392	$859	21.1	-1413	18.5	28.8	-5373	25.6

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.17/Watt)			High End Cost ($4.39/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
6	6/12	East	8820	$824	27.2	-4194	23.1	*	-8946	32.0
6	6/12	S East	9973	$945	23.2	-2691	20.1	*	-7443	27.9
6	6/12	South	10184	$1,048	20.6	-1417	18.1	28.0	-6168	25.1
6	6/12	S West	9410	$1,063	20.3	-1242	17.9	27.6	-5994	24.8
6	6/12	West	8096	$1,008	21.6	-1947	18.9	29.4	-6698	26.1
6	9/12	East	8551	$754	*	-5052	25.2	*	-9803	34.9
6	9/12	S East	9966	$899	24.5	-3250	21.1	*	-8002	29.3
6	9/12	South	10209	$1,031	21.0	-1629	18.4	28.5	-6381	25.5
6	9/12	S West	9264	$1,054	20.5	-1357	18.0	27.9	-6109	25.0
6	9/12	West	7671	$987	22.1	-2199	19.3	*	-6951	26.7
7	6/12	East	10290	$909	28.9	-5514	24.4	*	-11058	33.8
7	6/12	S East	11635	$1,039	24.7	-3876	21.4	*	-9419	29.6
7	6/12	South	11882	$1,157	21.8	-2412	19.2	29.6	-7956	26.6
7	6/12	S West	10978	$1,175	21.5	-2193	18.9	29.1	-7737	26.1
7	6/12	West	9445	$1,118	22.7	-2919	19.9	*	-8463	27.5
7	9/12	East	9976	$831	*	-6481	26.7	*	-12025	37.0
7	9/12	S East	11627	$990	26.1	-4494	22.4	*	-10038	31.1
7	9/12	South	11911	$1,141	22.2	-2629	19.5	*	-8173	26.9
7	9/12	S West	10808	$1,164	21.7	-2330	19.1	29.4	-7873	26.4
7	9/12	West	8949	$1,092	23.3	-3231	20.3	*	-8775	28.1
8	6/12	East	11760	$983	*	-6970	25.8	*	-13306	35.7
8	6/12	S East	13297	$1,121	26.3	-5233	22.6	*	-11569	31.3
8	6/12	South	13579	$1,246	23.2	-3650	20.3	*	-9985	28.2
8	6/12	S West	12547	$1,264	22.8	-3410	20.1	*	-9746	27.8
8	6/12	West	10795	$1,204	24.2	-4172	21.1	*	-10507	29.2
8	9/12	East	11402	$900	*	-8014	28.2	*	-14350	39.0
8	9/12	S East	13288	$1,069	27.8	-5886	23.7	*	-12221	32.8
8	9/12	South	13613	$1,232	23.6	-3840	20.6	*	-10176	28.5
8	9/12	S West	12352	$1,252	23.1	-3570	20.3	*	-9906	28.1
8	9/12	West	10228	$1,176	24.8	-4528	21.6	*	-10863	29.9
9	6/12	East	13230	$1,050	*	-8522	27.2	*	-15650	37.6
9	6/12	S East	14959	$1,198	27.9	-6675	23.8	*	-13803	33.0
9	6/12	South	15276	$1,327	24.7	-5030	21.5	*	-12157	29.8
9	6/12	S West	14115	$1,340	24.4	-4839	21.3	*	-11967	29.5
9	6/12	West	12144	$1,277	25.8	-5629	22.3	*	-12756	30.9
9	9/12	East	12827	$965	*	-9610	29.6	*	-16738	41.0
9	9/12	S East	14949	$1,143	29.5	-7369	25.0	*	-14496	34.6
9	9/12	South	15314	$1,312	25.0	-5218	21.7	*	-12346	30.1
9	9/12	S West	13896	$1,327	24.6	-5001	21.5	*	-12128	29.8
9	9/12	West	11506	$1,246	26.5	-6016	22.9	*	-13143	31.7
10	6/12	East	14700	$1,115	*	-10126	28.4	*	-18046	39.4

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.17/Watt)			High End Cost ($4.39/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
10	6/12	S East	16621	$1,269	29.5	-8182	25.0	*	-16101	34.6
10	6/12	South	16974	$1,401	26.2	-6496	22.6	*	-14416	31.3
10	6/12	S West	15683	$1,409	25.9	-6366	22.5	*	-14285	31.2
10	6/12	West	13493	$1,342	27.4	-7204	23.6	*	-15123	32.7
10	9/12	East	14252	$1,027	*	-11243	30.9	*	-19163	42.8
10	9/12	S East	16610	$1,213	*	-8900	26.1	*	-16819	36.2
10	9/12	South	17016	$1,387	26.5	-6683	22.9	*	-14602	31.7
10	9/12	S West	15440	$1,397	26.2	-6525	22.7	*	-14445	31.4
10	9/12	West	12785	$1,309	28.2	-7614	24.2	*	-15534	33.5

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APPENDIX K:
RESULTS FOR TAMPA, FL

TAMPA ELECTRIC, Fixed Monthly Charge: $15.12
Total Annual Load (kWh) = 14273
(* indicates no results due to payback period exceeding analysis period)

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.15/Watt)			High End Cost ($4.36/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
3	6/12	East	4074	$475	24.8	-6021	19.9	*	-4481	27.6
3	6/12	S East	4513	$520	22.2	-5431	18.2	*	-3928	25.2
3	6/12	South	4633	$532	21.6	-6691	17.8	*	-3785	24.6
3	6/12	S West	4388	$506	23.0	-9168	18.7	*	-4100	25.9
3	6/12	West	3901	$455	26.2	-8410	20.7	*	-4723	28.7
3	9/12	East	3912	$457	26.0	-6381	20.7	*	-4696	28.6
3	9/12	S East	4445	$512	22.6	-5825	18.5	*	-4024	25.5
3	9/12	South	4585	$525	22.0	-6957	18.0	*	-3865	24.9
3	9/12	S West	4286	$494	23.7	-9207	19.1	*	-4250	26.5
3	9/12	West	3696	$433	28.0	-9160	21.8	*	-5007	30.2
4	6/12	East	5432	$615	25.7	-6695	20.5	*	-6191	28.4
4	6/12	S East	6017	$675	22.9	-6045	18.7	*	-5453	25.8
4	6/12	South	6177	$692	22.3	-7432	18.2	*	-5251	25.2
4	6/12	S West	5851	$658	23.7	-10156	19.1	*	-5663	26.5
4	6/12	West	5202	$591	27.0	-9240	21.3	*	-6481	29.5
4	9/12	East	5216	$593	26.9	-7026	21.3	*	-6464	29.4
4	9/12	S East	5927	$666	23.3	-6420	18.9	*	-5567	26.2
4	9/12	South	6114	$685	22.5	-7654	18.4	*	-5331	25.5
4	9/12	S West	5714	$644	24.3	-10109	19.6	*	-5835	27.1
4	9/12	West	4928	$563	28.7	-10057	22.4	*	-6826	31.0
5	6/12	East	6790	$755	26.3	-7368	20.9	*	-7918	28.9
5	6/12	S East	7521	$830	23.4	-6660	19.0	*	-6996	26.3
5	6/12	South	7722	$851	22.7	-8172	18.5	*	-6743	25.6
5	6/12	S West	7314	$809	24.2	-11145	19.5	*	-7257	27.0
5	6/12	West	6502	$725	27.7	-6021	21.7	*	-8280	30.1
5	9/12	East	6520	$727	27.6	-5431	21.7	*	-8259	30.0
5	9/12	S East	7408	$818	23.8	-6691	19.2	*	-7138	26.6
5	9/12	South	7642	$842	23.0	-9168	18.7	*	-6843	25.9
5	9/12	S West	7143	$791	24.9	-8410	19.9	*	-7473	27.6
5	9/12	West	6160	$690	29.5	-6381	22.8	*	-8712	31.6
6	6/12	East	8148	$894	26.8	-5825	21.1	*	-9645	29.2
6	6/12	S East	9026	$985	23.8	-6957	19.2	*	-8538	26.6
6	6/12	South	9266	$1,010	23.1	-9207	18.7	*	-8235	25.9
6	6/12	S West	8776	$959	24.6	-9160	19.7	*	-8852	27.3

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.15/Watt)			High End Cost ($4.36/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
6	6/12	West	7803	$859	28.2	-6695	22.0	*	-10080	30.5
6	9/12	East	7823	$861	28.1	-6045	22.0	*	-10054	30.4
6	9/12	S East	8890	$971	24.2	-7432	19.5	*	-8709	26.9
6	9/12	South	9171	$1,000	23.3	-10156	18.9	*	-8355	26.2
6	9/12	S West	8571	$938	25.2	-9240	20.1	*	-9111	27.9
6	9/12	West	7392	$817	*	-7026	23.1	*	-10597	32.0
7	6/12	East	9505	$1,034	27.1	-6420	21.3	*	-11372	29.5
7	6/12	S East	10530	$1,140	24.0	-7654	19.3	*	-10081	26.8
7	6/12	South	10810	$1,168	23.3	-10109	18.9	*	-9727	26.1
7	6/12	S West	10239	$1,110	24.8	-10057	19.9	*	-10447	27.5
7	6/12	West	9103	$993	28.6	-7368	22.2	*	-11879	30.7
7	9/12	East	9127	$995	28.5	-6660	22.2	*	-11849	30.7
7	9/12	S East	10372	$1,123	24.5	-8172	19.6	*	-10280	27.2
7	9/12	South	10699	$1,157	23.6	-11145	19.1	*	-9867	26.4
7	9/12	S West	10000	$1,085	25.5	-6021	20.3	*	-10749	28.1
7	9/12	West	8624	$943	*	-5431	23.4	*	-12483	32.3
8	6/12	East	10863	$1,174	27.4	-6691	21.5	*	-13099	29.7
8	6/12	S East	12034	$1,294	24.2	-9168	19.5	*	-11623	26.9
8	6/12	South	12355	$1,327	23.5	-8410	19.0	*	-11219	26.3
8	6/12	S West	11702	$1,260	25.0	-6381	20.0	*	-12042	27.7
8	6/12	West	10404	$1,127	28.8	-5825	22.4	*	-13678	31.0
8	9/12	East	10431	$1,129	28.7	-6957	22.3	*	-13644	30.9
8	9/12	S East	11853	$1,276	24.7	-9207	19.8	*	-11851	27.3
8	9/12	South	12228	$1,314	23.8	-9160	19.2	*	-11379	26.5
8	9/12	S West	11428	$1,232	25.7	-6695	20.5	*	-12387	28.3
8	9/12	West	9856	$1,070	*	-6045	23.5	*	-14369	32.6
9	6/12	East	12221	$1,314	27.6	-7432	21.6	*	-14826	29.9
9	6/12	S East	13538	$1,449	24.4	-10156	19.6	*	-13165	27.1
9	6/12	South	13899	$1,486	23.6	-9240	19.1	*	-12711	26.4
9	6/12	S West	13165	$1,411	25.2	-7026	20.1	*	-13637	27.8
9	6/12	West	11704	$1,261	29.1	-6420	22.5	*	-15478	31.1
9	9/12	East	11735	$1,264	29.0	-7654	22.4	*	-15439	31.1
9	9/12	S East	13335	$1,428	24.8	-10109	19.8	*	-13422	27.5
9	9/12	South	13756	$1,472	23.9	-10057	19.3	*	-12891	26.7
9	9/12	S West	12857	$1,379	25.9	-7368	20.6	*	-14025	28.5
9	9/12	West	11088	$1,197	*	-6660	23.7	*	-16255	32.8
10	6/12	East	13579	$1,454	27.7	-8172	21.7	*	-16553	30.0
10	6/12	S East	15043	$1,604	24.5	-11145	19.6	*	-14708	27.2
10	6/12	South	15443	$1,645	23.7	-6021	19.1	*	-14203	26.5
10	6/12	S West	14627	$1,561	25.3	-5431	20.2	*	-15231	27.9
10	6/12	West	13005	$1,394	29.2	-6691	22.6	*	-17277	31.3

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.15/Watt)			High End Cost ($4.36/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
10	9/12	East	13039	$1,398	29.1	-9168	22.5	*	-17234	31.2
10	9/12	S East	14816	$1,581	24.9	-8410	19.9	*	-14993	27.6
10	9/12	South	15284	$1,629	24.0	-6381	19.3	*	-14403	26.8
10	9/12	S West	14285	$1,526	26.1	-5825	20.6	*	-15663	28.6
10	9/12	West	12320	$1,324	*	-6957	23.8	*	-18140	32.9

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APPENDIX L:
RESULTS FOR BOSTON, MA

EVERSOURCE, Net Metering, Fixed Monthly Charge $7
Total Annual Load (kWh) = 25820
(* indicates no results due to payback period exceeding analysis period)

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.27/Watt)			High End Cost ($4.53/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
3	6/12	East	3225	$678	16.2	14.5	14.5	22.6	-1575	20.0
3	6/12	S East	3765	$791	13.7	12.4	12.4	19.1	-196	17.2
3	6/12	South	3971	$834	12.9	11.8	11.8	18.0	331	16.3
3	6/12	S West	3740	$786	13.8	12.5	12.5	19.2	-260	17.3
3	6/12	West	3196	$672	16.4	14.6	14.6	22.8	-1651	20.2
3	9/12	East	3127	$658	16.8	14.9	14.9	23.4	-1826	20.7
3	9/12	S East	3788	$796	13.6	12.3	12.3	19.0	-137	17.1
3	9/12	South	4039	$848	12.7	11.6	11.6	17.7	502	16.0
3	9/12	S West	3753	$789	13.8	12.4	12.4	19.2	-227	17.2
3	9/12	West	3092	$650	17.0	15.1	15.1	23.7	-1918	20.9
4	6/12	East	4300	$905	16.2	14.5	14.5	22.6	-2101	20.0
4	6/12	S East	5019	$1,055	13.7	12.4	12.4	19.1	-261	17.2
4	6/12	South	5295	$1,112	12.9	11.8	11.8	18.0	441	16.3
4	6/12	S West	4987	$1,048	13.8	12.5	12.5	19.2	-346	17.3
4	6/12	West	4261	$896	16.4	14.6	14.6	22.8	-2202	20.2
4	9/12	East	4169	$877	16.8	14.9	14.9	23.4	-2435	20.7
4	9/12	S East	5050	$1,061	13.6	12.3	12.3	19.0	-183	17.1
4	9/12	South	5385	$1,131	12.7	11.6	11.6	17.7	669	16.0
4	9/12	S West	5004	$1,051	13.8	12.4	12.4	19.2	-302	17.2
4	9/12	West	4122	$867	17.0	15.1	15.1	23.7	-2558	20.9
5	6/12	East	5375	$1,131	16.2	14.5	14.5	22.6	-2626	20.0
5	6/12	S East	6274	$1,318	13.7	12.4	12.4	19.1	-326	17.2
5	6/12	South	6619	$1,390	12.9	11.8	11.8	18.0	551	16.3
5	6/12	S West	6234	$1,310	13.8	12.5	12.5	19.2	-433	17.3
5	6/12	West	5326	$1,120	16.4	14.6	14.6	22.8	-2752	20.2
5	9/12	East	5211	$1,097	16.8	14.9	14.9	23.4	-3044	20.7
5	9/12	S East	6313	$1,326	13.6	12.3	12.3	19.0	-228	17.1
5	9/12	South	6731	$1,413	12.7	11.6	11.6	17.7	837	16.0
5	9/12	S West	6256	$1,314	13.8	12.4	12.4	19.2	-378	17.2
5	9/12	West	5153	$1,084	17.0	15.1	15.1	23.7	-3197	20.9
6	6/12	East	6450	$1,357	16.2	14.5	14.5	22.6	-3151	20.0
6	6/12	S East	7529	$1,582	13.7	12.4	12.4	19.1	-392	17.2
6	6/12	South	7942	$1,668	12.9	11.8	11.8	18.0	661	16.3
6	6/12	S West	7480	$1,572	13.8	12.5	12.5	19.2	-519	17.3

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.27/Watt)			High End Cost ($4.53/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
6	6/12	West	6392	$1,344	16.4	14.6	14.6	22.8	-3302	20.2
6	9/12	East	6254	$1,316	16.8	14.9	14.9	23.4	-3653	20.7
6	9/12	S East	7576	$1,592	13.6	12.3	12.3	19.0	-274	17.1
6	9/12	South	8078	$1,696	12.7	11.6	11.6	17.7	1004	16.0
6	9/12	S West	7507	$1,577	13.8	12.4	12.4	19.2	-453	17.2
6	9/12	West	6183	$1,301	17.0	15.1	15.1	23.7	-3837	20.9
7	6/12	East	7525	$1,583	16.2	14.5	14.5	22.6	-3676	20.0
7	6/12	S East	8784	$1,846	13.7	12.4	12.4	19.1	-457	17.2
7	6/12	South	9266	$1,946	12.9	11.8	11.8	18.0	772	16.3
7	6/12	S West	8727	$1,834	13.8	12.5	12.5	19.2	-606	17.3
7	6/12	West	7457	$1,569	16.4	14.6	14.6	22.8	-3853	20.2
7	9/12	East	7296	$1,535	16.8	14.9	14.9	23.4	-4262	20.7
7	9/12	S East	8838	$1,857	13.6	12.3	12.3	19.0	-319	17.1
7	9/12	South	9424	$1,979	12.7	11.6	11.6	17.7	1171	16.0
7	9/12	S West	8758	$1,840	13.8	12.4	12.4	19.2	-529	17.2
7	9/12	West	7214	$1,518	17.0	15.1	15.1	23.7	-4476	20.9
8	6/12	East	8600	$1,809	16.2	14.5	14.5	22.6	-4201	20.0
8	6/12	S East	10039	$2,109	13.7	12.4	12.4	19.1	-524	17.2
8	6/12	South	10590	$2,223	12.9	11.8	11.8	18.0	876	16.3
8	6/12	S West	9974	$2,095	13.8	12.5	12.5	19.2	-695	17.3
8	6/12	West	8522	$1,793	16.4	14.6	14.6	22.8	-4403	20.2
8	9/12	East	8338	$1,754	16.8	14.9	14.9	23.4	-4871	20.7
8	9/12	S East	10101	$2,122	13.6	12.3	12.3	19.0	-365	17.1
8	9/12	South	10770	$2,261	12.7	11.6	11.6	17.7	1337	16.0
8	9/12	S West	10009	$2,103	13.8	12.4	12.4	19.2	-605	17.2
8	9/12	West	8244	$1,734	17.0	15.1	15.1	23.7	-5116	20.9
9	6/12	East	9675	$2,032	16.2	14.5	14.5	22.6	-4744	20.1
9	6/12	S East	11294	$2,367	13.7	12.4	12.4	19.1	-634	17.2
9	6/12	South	11913	$2,495	13.0	11.8	11.8	18.1	935	16.3
9	6/12	S West	11220	$2,351	13.8	12.5	12.5	19.3	-832	17.3
9	6/12	West	9588	$2,012	16.4	14.6	14.6	22.9	-4978	20.3
9	9/12	East	9380	$1,973	16.8	14.9	14.9	23.4	-5482	20.7
9	9/12	S East	11363	$2,384	13.6	12.3	12.3	19.0	-437	17.1
9	9/12	South	12116	$2,539	12.7	11.6	11.6	17.7	1471	16.1
9	9/12	S West	11260	$2,361	13.8	12.5	12.5	19.2	-711	17.3
9	9/12	West	9275	$1,950	17.0	15.1	15.1	23.7	-5760	20.9
10	6/12	East	10750	$2,252	16.3	14.5	14.5	22.7	-5336	20.1
10	6/12	S East	12548	$2,623	13.8	12.5	12.5	19.2	-782	17.3
10	6/12	South	13237	$2,764	13.0	11.8	11.8	18.1	951	16.4
10	6/12	S West	12467	$2,605	13.9	12.6	12.6	19.3	-1003	17.4
10	6/12	West	10653	$2,230	16.4	14.7	14.7	22.9	-5600	20.3

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.27/Watt)			High End Cost ($4.53/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
10	9/12	East	10423	$2,187	16.8	15.0	15.0	23.4	-6136	20.7
10	9/12	S East	12626	$2,642	13.7	12.4	12.4	19.0	-555	17.1
10	9/12	South	13463	$2,813	12.8	11.6	11.6	17.8	1551	16.1
10	9/12	S West	12511	$2,616	13.8	12.5	12.5	19.2	-863	17.3
10	9/12	West	10305	$2,161	17.0	15.1	15.1	23.7	-6455	21.0

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APPENDIX M:
RESULTS FOR KANSAS CITY, MO

KANSAS CITY POWER AND LIGHTS (KCP&L), Net Metering, Fixed Monthly Charge: $11.47
Total Annual Load (kWh) = 24178
(* indicates no results due to payback period exceeding analysis period)

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.22/Watt)			High End Cost ($4.46/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
3	6/12	East	3487	$388	28.3	-2827	24.9	*	-5503	34.5
3	6/12	S East	4050	$438	26.7	-2204	22.0	*	-4879	30.5
3	6/12	South	4286	$459	28.0	-1949	21.0	*	-4624	29.1
3	6/12	S West	4076	$443	*	-2152	21.8	*	-4827	30.2
3	6/12	West	3517	$393	*	-2761	24.6	*	-5437	34.1
3	9/12	East	3359	$372	28.7	-3023	26.0	*	-5699	36.0
3	9/12	S East	4047	$433	26.8	-2264	22.3	*	-4940	30.9
3	9/12	South	4332	$458	28.3	-1968	21.1	*	-4643	29.2
3	9/12	S West	4081	$439	*	-2197	22.0	*	-4873	30.5
3	9/12	West	3398	$378	*	-2941	25.5	*	-5616	35.4
4	6/12	East	4649	$521	28.1	-3719	24.7	*	-7287	34.3
4	6/12	S East	5401	$589	26.5	-2888	21.9	*	-6456	30.3
4	6/12	South	5714	$617	27.7	-2544	20.9	*	-6112	28.9
4	6/12	S West	5435	$594	*	-2818	21.7	*	-6386	30.0
4	6/12	West	4690	$528	*	-3631	24.4	*	-7199	33.8
4	9/12	East	4478	$499	28.5	-3980	25.8	*	-7548	35.7
4	9/12	S East	5396	$582	26.5	-2969	22.1	*	-6536	30.7
4	9/12	South	5776	$616	28.0	-2557	20.9	*	-6125	28.9
4	9/12	S West	5442	$589	*	-2879	21.9	*	-6447	30.3
4	9/12	West	4530	$508	*	-3871	25.3	*	-7438	35.1
5	6/12	East	5812	$656	27.7	-4589	24.5	*	-9048	34.0
5	6/12	S East	6751	$747	26.0	-3500	21.6	*	-7960	29.9
5	6/12	South	7143	$786	27.3	-3019	20.5	*	-7479	28.4
5	6/12	S West	6794	$754	*	-3412	21.4	*	-7872	29.6
5	6/12	West	5862	$665	*	-4486	24.2	*	-8945	33.5
5	9/12	East	5598	$629	28.0	-4924	25.6	*	-9383	35.4
5	9/12	S East	6745	$740	26.0	-3590	21.8	*	-8050	30.2
5	9/12	South	7220	$786	27.6	-3024	20.5	*	-7483	28.4
5	9/12	S West	6802	$749	*	-3476	21.5	*	-7935	29.8
5	9/12	West	5663	$640	*	-4794	25.2	*	-9253	34.9
6	6/12	East	6974	$794	27.2	-5428	24.3	*	-10780	33.7
6	6/12	S East	8101	$908	25.5	-4044	21.3	*	-9396	29.5
6	6/12	South	8572	$956	26.9	-3466	20.2	*	-8817	28.0
6	6/12	S West	8153	$917	*	-3938	21.1	*	-9290	29.2

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.22/Watt)			High End Cost ($4.46/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
6	6/12	West	7035	$805	*	-5303	24.0	*	-10655	33.3
6	9/12	East	6718	$761	27.5	-5832	25.4	*	-11183	35.2
6	9/12	S East	8095	$900	25.5	-4152	21.5	*	-9503	29.7
6	9/12	South	8664	$955	27.1	-3472	20.2	*	-8823	28.0
6	9/12	S West	8162	$911	*	-4014	21.2	*	-9365	29.4
6	9/12	West	6795	$774	*	-5678	25.0	*	-11029	34.6
7	6/12	East	8136	$936	26.8	-6227	24.1	*	-12470	33.3
7	6/12	S East	9451	$1,070	25.2	-4588	21.1	*	-10831	29.2
7	6/12	South	10000	$1,125	26.5	-3913	20.0	*	-10156	27.7
7	6/12	S West	9512	$1,080	*	-4464	20.9	*	-10707	28.9
7	6/12	West	8207	$949	*	-6071	23.8	*	-12314	32.9
7	9/12	East	7837	$897	27.2	-6708	25.1	*	-12951	34.8
7	9/12	S East	9444	$1,060	25.2	-4713	21.3	*	-10956	29.5
7	9/12	South	10108	$1,125	26.7	-3920	20.0	*	-10163	27.8
7	9/12	S West	9523	$1,073	*	-4552	21.0	*	-10795	29.1
7	9/12	West	7928	$913	*	-6514	24.7	*	-12757	34.2
8	6/12	East	9299	$1,079	26.6	-7005	23.9	*	-14140	33.1
8	6/12	S East	10801	$1,232	25.0	-5131	20.9	*	-12266	29.0
8	6/12	South	11429	$1,295	26.3	-4360	19.9	*	-11495	27.6
8	6/12	S West	10870	$1,243	*	-4990	20.7	*	-12125	28.7
8	6/12	West	9380	$1,093	*	-6826	23.6	*	-13961	32.6
8	9/12	East	8957	$1,034	26.9	-7555	24.9	*	-14690	34.5
8	9/12	S East	10793	$1,220	25.0	-5274	21.1	*	-12409	29.2
8	9/12	South	11552	$1,294	26.5	-4367	19.9	*	-11503	27.6
8	9/12	S West	10883	$1,235	*	-5090	20.9	*	-12226	28.9
8	9/12	West	9061	$1,052	*	-7332	24.5	*	-14468	33.9
9	6/12	East	10461	$1,221	26.4	-7782	23.7	*	-15809	32.9
9	6/12	S East	12151	$1,393	24.8	-5674	20.8	*	-13701	28.8
9	6/12	South	12857	$1,464	26.1	-4807	19.8	*	-12834	27.4
9	6/12	S West	12229	$1,406	*	-5515	20.6	*	-13542	28.5
9	6/12	West	10552	$1,237	*	-7581	23.4	*	-15609	32.4
9	9/12	East	10076	$1,170	26.7	-8401	24.8	*	-16429	34.3
9	9/12	S East	12142	$1,380	24.8	-5835	21.0	*	-13862	29.1
9	9/12	South	12996	$1,463	26.3	-4815	19.8	*	-12842	27.4
9	9/12	S West	12243	$1,397	*	-5629	20.7	*	-13656	28.7
9	9/12	West	10193	$1,191	*	-8151	24.3	*	-16178	33.7
10	6/12	East	11623	$1,360	26.3	-8571	23.7	*	-17490	32.8
10	6/12	S East	13502	$1,541	24.8	-6277	20.9	*	-15197	28.9
10	6/12	South	14286	$1,610	26.0	-5389	20.0	*	-14308	27.7
10	6/12	S West	13588	$1,554	*	-6108	20.7	*	-15027	28.7
10	6/12	West	11725	$1,378	*	-8347	23.4	*	-17266	32.4

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.22/Watt)			High End Cost ($4.46/Watt)		
kW	*Roof Pitch*	*Compass Direction*	*kWh*	*Value*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*	*Normalized Simple Payback, years*	*Net Present Value*	*Simple Payback, years*
10	9/12	East	11196	$1,307	26.6	-9248	24.6	*	-18167	34.1
10	9/12	S East	13491	$1,531	24.8	-6423	21.0	*	-15342	29.1
10	9/12	South	14439	$1,614	26.2	-5374	20.0	*	-14293	27.6
10	9/12	S West	13604	$1,548	*	-6204	20.8	*	-15123	28.8
10	9/12	West	11326	$1,330	*	-8969	24.2	*	-17889	33.5

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APPENDIX N:
RESULTS FOR SEATTLE, WA

PUGET SOUND AND ENERGY, Net Metering, Fixed Monthly Charge $7.99
Total Annual Load (kWh) = 20515
(* indicates no results due to payback period exceeding analysis period)

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.23/Watt)			High End Cost ($4.47/Watt)		
kW	***Roof Pitch***	***Compass Direction***	***kWh***	***Value***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***
3	6/12	East	2785	$298	*	-3464	32.5	*	-5958	45.0
3	6/12	S East	3272	$350	*	-2824	27.6	*	-5319	38.3
3	6/12	South	3491	$374	29.8	-2537	25.9	*	-5032	35.9
3	6/12	S West	3340	$358	*	-2735	27.1	*	-5230	37.5
3	6/12	West	2881	$309	*	-3337	31.4	*	-5831	43.5
3	9/12	East	2665	$285	*	-3621	34.0	*	-6115	47.0
3	9/12	S East	3264	$350	*	-2835	27.7	*	-5330	38.4
3	9/12	South	3533	$378	29.4	-2482	25.6	*	-4977	35.4
3	9/12	S West	3349	$359	*	-2723	27.0	*	-5218	37.4
3	9/12	West	2784	$298	*	-3464	32.5	*	-5959	45.0
4	6/12	East	3713	$398	*	-4618	32.5	*	-7945	45.0
4	6/12	S East	4363	$467	*	-3765	27.7	*	-7092	38.3
4	6/12	South	4654	$498	29.8	-3386	26.0	*	-6712	35.9
4	6/12	S West	4453	$477	*	-3648	27.1	*	-6975	37.5
4	6/12	West	3842	$411	*	-4449	31.4	*	-7775	43.5
4	9/12	East	3553	$381	*	-4828	34.0	*	-8154	47.0
4	9/12	S East	4352	$466	*	-3780	27.7	*	-7106	38.4
4	9/12	South	4710	$504	29.4	-3312	25.6	*	-6638	35.5
4	9/12	S West	4466	$478	*	-3631	27.0	*	-6958	37.4
4	9/12	West	3712	$398	*	-4619	32.5	*	-7946	45.0
5	6/12	East	4641	$493	*	-5797	32.7	*	-9955	45.3
5	6/12	S East	5454	$577	*	-4769	28.0	*	-8927	38.7
5	6/12	South	5818	$614	*	-4314	26.3	*	-8472	36.4
5	6/12	S West	5567	$588	*	-4640	27.5	*	-8797	38.0
5	6/12	West	4802	$508	*	-5612	31.8	*	-9770	44.0
5	9/12	East	4441	$474	*	-6041	34.1	*	-10199	47.1
5	9/12	S East	5440	$577	*	-4771	28.0	*	-8929	38.7
5	9/12	South	5888	$622	29.6	-4209	25.9	*	-8367	35.9
5	9/12	S West	5582	$590	*	-4608	27.4	*	-8765	37.9
5	9/12	West	4640	$493	*	-5806	32.8	*	-9964	45.4
6	6/12	East	5569	$585	*	-7044	33.1	*	-12033	45.8
6	6/12	S East	6545	$683	*	-5834	28.4	*	-10823	39.3
6	6/12	South	6981	$727	*	-5295	26.7	*	-10285	36.9
6	6/12	S West	6680	$695	*	-5680	27.9	*	-10669	38.6

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.23/Watt)			High End Cost ($4.47/Watt)		
kW	***Roof Pitch***	***Compass Direction***	***kWh***	***Value***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***
6	6/12	West	5763	$603	*	-6822	32.1	*	-11812	44.5
6	9/12	East	5330	$562	*	-7326	34.5	*	-12316	47.7
6	9/12	S East	6528	$683	*	-5835	28.4	*	-10824	39.3
6	9/12	South	7066	$738	*	-5167	26.3	*	-10156	36.4
6	9/12	S West	6698	$699	*	-5639	27.7	*	-10629	38.4
6	9/12	West	5568	$584	*	-7055	33.2	*	-12044	45.9
7	6/12	East	6497	$673	*	-8323	33.6	*	-14144	46.5
7	6/12	S East	7635	$787	*	-6929	28.7	*	-12750	39.8
7	6/12	South	8145	$838	*	-6302	27.0	*	-12123	37.3
7	6/12	S West	7793	$802	*	-6750	28.2	*	-12571	39.0
7	6/12	West	6723	$694	*	-8069	32.6	*	-13890	45.1
7	9/12	East	6218	$647	*	-8640	34.9	*	-14461	48.3
7	9/12	S East	7616	$787	*	-6925	28.7	*	-12746	39.7
7	9/12	South	8243	$851	*	-6150	26.6	*	-11971	36.8
7	9/12	S West	7815	$806	*	-6700	28.1	*	-12521	38.8
7	9/12	West	6496	$673	*	-8327	33.6	*	-14148	46.5
8	6/12	East	7425	$761	*	-9620	34.0	*	-16273	47.0
8	6/12	S East	8726	$891	*	-8027	29.0	*	-14680	40.1
8	6/12	South	9309	$949	*	-7311	27.2	*	-13964	37.7
8	6/12	S West	8907	$908	*	-7823	28.5	*	-14476	39.4
8	6/12	West	7683	$785	*	-9330	32.9	*	-15982	45.6
8	9/12	East	7106	$731	*	-9981	35.3	*	-16633	48.9
8	9/12	S East	8704	$891	*	-8023	29.0	*	-14676	40.1
8	9/12	South	9421	$964	*	-7137	26.8	*	-13790	37.1
8	9/12	S West	8931	$912	*	-7766	28.3	*	-14419	39.2
8	9/12	West	7424	$761	*	-9624	34.0	*	-16277	47.0
9	6/12	East	8354	$849	*	-10918	34.3	*	-18402	47.4
9	6/12	S East	9817	$996	*	-9125	29.2	*	-16609	40.4
9	6/12	South	10472	$1,064	*	-8309	27.3	*	-15793	37.8
9	6/12	S West	10020	$1,016	*	-8889	28.6	*	-16373	39.6
9	6/12	West	8644	$875	*	-10591	33.2	*	-18075	46.0
9	9/12	East	7995	$816	*	-11323	35.6	*	-18807	49.3
9	9/12	S East	9792	$995	*	-9121	29.2	*	-16605	40.4
9	9/12	South	10598	$1,078	*	-8123	27.0	*	-15607	37.3
9	9/12	S West	10048	$1,020	*	-8832	28.5	*	-16316	39.4
9	9/12	West	8352	$848	*	-10922	34.3	*	-18406	47.4
10	6/12	East	9282	$938	*	-12213	34.4	*	-20529	47.7
10	6/12	S East	10908	$1,103	*	-10180	29.3	*	-18496	40.5
10	6/12	South	11636	$1,173	*	-9300	27.5	*	-17616	38.1
10	6/12	S West	11133	$1,123	*	-9924	28.8	*	-18239	39.8
10	6/12	West	9604	$971	*	-11828	33.3	*	-20144	46.0

PV Array Size, Tilt and Azimuth			System Energy Production Year 1		Low End Cost ($3.23/Watt)			High End Cost ($4.47/Watt)		
kW	***Roof Pitch***	***Compass Direction***	***kWh***	***Value***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***	***Normalized Simple Payback, years***	***Net Present Value***	***Simple Payback, years***
10	9/12	East	8883	$900	*	-12666	35.9	*	-20982	49.7
10	9/12	S East	10880	$1,103	*	-10187	29.3	*	-18502	40.5
10	9/12	South	11776	$1,190	*	-9095	27.1	*	-17411	37.6
10	9/12	S West	11164	$1,128	*	-9861	28.6	*	-18177	39.6
10	9/12	West	9280	$938	*	-12216	34.4	*	-20531	47.7

APPENDIX O:
RATE SCHEDULE- ARIZONA PUBLIC SERVICES CO.

aps

RATE SCHEDULE TOU-E
RESIDENTIAL TIME-OF-USE SERVICE
SAVER CHOICE

AVAILABILITY

This rate schedule is available to all residential Customers, including Partial Requirements Customers with an on-site distributed generation system.

DESCRIPTION

This rate has two parts: a basic service charge and an energy charge. The energy charge will vary by season (summer or winter) and by the time of day that the energy is used (On-Peak or Off-Peak). This rate does not include a demand charge.

TIME PERIODS

The On-Peak time period for residential rate schedules is 3 p.m. to 8 p.m. Monday through Friday year round. This rate also has a Super Off-Peak period, which is 10 a.m. to 3 p.m. Monday through Friday during the winter billing cycles of November through April. All other hours are Off-Peak hours.

The following holidays are also included in the Off-Peak hours:

- New Year's Day - January 1*
- Martin Luther King Day - Third Monday in January
- Presidents Day - Third Monday in February
- Cesar Chavez Day - March 31*
- Memorial Day - Last Monday in May
- Independence Day - July 4*
- Labor Day - First Monday in September
- Veterans Day - November 11*
- Thanksgiving - Fourth Thursday in November
- Christmas Day - December 25*

*If these holidays fall on a Saturday, the preceding Friday will be Off-peak. If they fall on a Sunday, the following Monday will be Off-Peak.

The rate also varies by summer and winter seasons. The summer season is the May through October billing cycles and the winter season is the November through April billing cycles.

CHARGES

The monthly bill will consist of the following charges, plus adjustments:

Bundled Charges

Basic Service Charge	$0.427	per day

Bundled Charges continued:

	Summer	Winter	
On-Peak Energy Charge	$0.24314	$0.23068	per kWh
Off-Peak Energy Charge	$0.10873	$0.10873	per kWh
Super Off-Peak Energy Charge		$0.03200	per kWh

Unbundled Components of the Bundled Charges

Bundled Charges consist of the components shown below. These are not additional charges.

Basic Service Charge Components

Customer Accounts Charge	$0.073	per day
Metering Charge	$0.201	per day
Meter Reading Charge	$0.072	per day
Billing Charge	$0.081	per day

Energy Charge Components

System Benefits Charge	$0.00276	per kWh
Transmission Charge	$0.01097	per kWh

	Summer	Winter	
Delivery Charge On-Peak	$0.03112	$0.03112	per kWh
Delivery Charge Off-Peak	$0.03112	$0.03112	per kWh
Delivery Charge Super Off-Peak	N/A	$0.01105	per kWh
Generation On-Peak Charge	$0.19829	$0.18583	per kWh
Generation Off-Peak Charge	$0.06388	$0.06388	per kWh
Generation Super Off-Peak Charge		$0.00722	per kWh

CHARGE FOR ON-SITE DISTRIBUTED GENERATION CUSTOMERS

The monthly bill for Customers on this rate schedule that have an on-site distributed generation system will also include a Grid Access Charge. This charge will apply to the nameplate kW-dc power rating of the Customer's distributed generation facility:

Grid Access Charge	$0.93	per kW-dc of generation

ADJUSTMENTS

The bill will include the following adjustments:

1. The Renewable Energy Adjustment Charge, Adjustment Schedule REAC-1.
2. The Power Supply Adjustment charge, Adjustment Schedule PSA-1.
3. The Transmission Cost Adjustment charge, Adjustment Schedule TCA-1.
4. The Environmental Improvement Surcharge, Adjustment Schedule EIS.
5. The Demand Side Management Adjustment charge, Adjustment Schedule DSMAC-1.
6. The Lost Fixed Cost Recovery Adjustment charge, Adjustment Schedule LFCR.
7. The Tax Expense Adjustor Mechanism charge, Adjustment Schedule TEAM.
8. Direct Access customers returning to Standard Offer service may be subject to a Returning Customer Direct Access Charge, Adjustment Schedule RCDAC-1.
9. Any applicable taxes and governmental fees that are assessed on APS's revenues, prices, sales volume, or generation volume.

RATE RIDERS

Eligible rate riders for this rate schedule are:

CPP (RES)	Critical Peak Pricing (Residential)
EPR-2	Partial Requirements
EPR-6	Partial Requirements – Net Metering (Residential Non-Solar)
RCP	Resource Comparison Proxy
E-3	Limited income discount
E-4	Limited income medical discount
GPS-1, GPS-2, GPS-3	Green Power

SERVICE DETAILS

RATE RIDER RCP
PARTIAL REQUIREMENTS SERVICE FOR NEW ON-SITE SOLAR DISTRIBUTED GENERATION RESOURCE COMPARISON PROXY EXPORT RATE

AVAILABILITY

This rate rider is available to partial requirements customers with qualified on-site solar generation, served under an applicable residential rate. This rate rider may not be used in conjunction with a grandfathered residential Legacy rate schedule or Legacy rate rider.

DESCRIPTION

A Customer with solar generation exports power to the grid from time to time when their generation exceeds the load in their home. The Company will meter this export power on an instantaneous basis and provide a monthly bill credit based on the purchase rate in this schedule.

The purchase rates will be determined as follows:

a. An RCP rate will be determined for each annual tranche of new DG Customers, effective September 1 each year without proration. The RCP rate may not be reduced by more than 10% each year.

b. Each Customer's bill credit will initially be based on the RCP in effect at the time they submit an interconnection application for their system before September 1 provided that they subsequently complete the installation and obtain approval by the appropriate Authority Having Jurisdiction within 180 days of their interconnection application unless, through no fault of the Customer or the Customer's installer, the interconnection is delayed by a third party or APS. In that circumstance, the Customer will have 270 days to complete their interconnection.

c. Each Customer's initial RCP rate will be applicable for 10 years from the time of their interconnection.

d. After each Customer's initial 10 year period the bill credit will be based on the purchase rate in effect at that time, and may change from year to year.

Further details are provided in the Resource Comparison Proxy Plan of Administration and Arizona Corporation Commission Decisions No. 75859 and 76295.

PURCHASE RATES

The Company will provide a bill credit for the exported energy based on the following purchase rates:

Tranche 2017	September 1, 2017 through September 30, 2018	\$0.1290	per kWh
Tranche 2018	October 1, 2018 through August 31, 2019	\$0.1161	per kWh
Tranche 2019	September 1, 2019 through August 31, 2020	\$0.1045	per kWh

Any bill credit in excess of the Customer's otherwise applicable monthly bill will be credited on the next monthly bill, or subsequent bills if necessary. After the Customer's December bill, a Customer may request a check for any outstanding credits from the prior year; however, if the outstanding credits exceed \$25, the Company will automatically issue a check to the Customer. Otherwise, the bill credits will carry forward to the following year.

GENERATOR REQUIREMENTS

Distributed generators must meet all of the following qualifications:

1. Electricity must be generated using solar photovoltaic panels;

2. The generator must be interconnected to the Company's distribution grid;

3. The generator must be on-site, installed behind the billing meter, and must serve the Customer's load;

4. The facility's nameplate capacity cannot be larger than the following electrical service limits:
    a. For 200 Amp service, a maximum of 15 kW-dc.
    b. For 400 Amp service, a maximum of 30 kW-dc.
    c. For 600 Amp service, a maximum of 45 kW-dc.
    d. For 800 Amp service and above, a maximum of 60 kW-dc; and

5. For systems over 10 kW-dc, the facility's nameplate capacity cannot be larger than 150% of the customer's maximum one-hour peak demand measured in AC over the prior twelve (12) months. (For example, if the customer's peak is 8 kW-ac, the maximum system size that could be installed would be 12 kW-dc).

SPECIAL CASES

1. Switching from a grandfathered legacy solar rate. A Customer may switch from a grandfathered solar Legacy rate and net metering rider to a new retail rate and the RCP rider. However, they will lose their grandfathering status and may not subsequently switch back to

RATE RIDER EPR-2
PARTIAL REQUIREMENTS SERVICE FOR QUALIFIED FACILITIES OF 100 kW OR LESS

AVAILABILITY

This rate rider is available to Customers with a qualifying on-site cogeneration or small power production facility (QF) with a generating nameplate capacity of 100 kW-ac or less which is interconnected to the Company's distribution grid. Contracts between APS and QFs larger than 100kw will be consistent with Decision Nos. 52345 and 77512.

DESCRIPTION

This rate rider describes how the Company will bill a Customer with an on-site Qualifying Facility (QF). A partial requirements Customer has on-site generation that serves some of their electrical needs and relies on the Company for additional electrical services. Export energy occurs when the Customer's generation is greater than their electrical load in any instant and this excess energy flows back to the Company's grid.

TIME PERIODS

The On-Peak and Off-Peak purchase rates below will be applied to the specific On-Peak and Off-Peak hours under a Customer's retail rate. If the Customer's retail rate has a Shoulder-Peak period, these hours will be credited at the On-Peak purchase rate.

The summer season is the May through October billing cycles and the winter season is the November through April billing cycles.

PURCHASE RATES

The export energy will be acquired by the Company in exchange for a credit on the Customer's monthly bill, based on the following rates for summer and winter seasons:

	Summer	Winter	
On-Peak Non-Firm Rate	$0.02989	$0.03040	per kWh
Off-Peak Non-Firm Rate	$0.02897	$0.02831	per kWh
On-Peak Firm Rate	$0.04297	$0.03040	per kWh
Off-Peak Firm Rate	$0.03009	$0.02831	per kWh

BILLING DETAILS

All terms and charges in the Customer's rate schedule continue to apply to electric service provided under this rider.

APPENDIX P:
RATE SCHEDULE- TAMPA ELECTRIC CO.

TECO TAMPA ELECTRIC AN EMERA COMPANY

TWENTY-FOURTH REVISED SHEET NO. 6.030
CANCELS TWENTY-THIRD REVISED SHEET NO. 6.030

RESIDENTIAL SERVICE

SCHEDULE: RS

AVAILABLE: Entire service area.

APPLICABLE: To residential consumers in individually metered private residences, apartment units, and duplex units. All energy must be for domestic purposes and should not be shared with or sold to others. In addition, energy used in commonly-owned facilities in condominium and cooperative apartment buildings will qualify for this rate schedule, subject to the following criteria:

1. 100% of the energy is used exclusively for the co-owners' benefit.
2. None of the energy is used in any endeavor which sells or rents a commodity or provides service for a fee.
3. Each point of delivery will be separately metered and billed.
4. A responsible legal entity is established as the customer to whom the Company can render its bills for said service.

Resale not permitted.

Billing charges shall be prorated for billing periods that are less than 25 days or greater than 35 days. If the billing period exceeds 35 days and the billing extension causes energy consumption, based on average daily usage, to exceed 1,000 kWh, the excess consumption will be charged at the lower monthly Energy and Demand Charge.

LIMITATION OF SERVICE: This schedule includes service to single phase motors rated up to 7.5 HP. Three phase service may be provided where available for motors rated 7.5 HP and over.

MONTHLY RATE:

Basic Service Charge:
$15.12

Energy and Demand Charge:

First 1,000 kWh	5.141¢ per kWh
All additional kWh	6.141¢ per kWh

MINIMUM CHARGE: The Basic Service Charge.

FUEL CHARGE: See Sheet Nos. 6.020 and 6.021.

Continued to Sheet No. 6.031

ISSUED BY: N. G. Tower, President

DATE EFFECTIVE: January 1, 2019

ADDITIONAL BILLING CHARGES

TOTAL FUEL AND PURCHASED POWER COST RECOVERY CLAUSE: The total fuel and purchased power cost recovery factor shall be applied to each kilowatt-hour delivered, and shall be computed in accordance with the formula prescribed by the Florida Public Service Commission. The following fuel recovery factors by rate schedule have been approved by the Commission:

RECOVERY PERIOD
(April 2019 through December 2019)

Rate Schedules		¢/kWh Fuel Standard	¢/kWh Fuel Peak	¢/kWh Fuel Off-Peak	¢/kWh Energy Conservation	¢/kWh Capacity	¢/kWh Environmental
RS (up to 1,000 kWh)		2.913			0.321	(0.010)	0.222
RS (over 1,000 kWh)		3.913			0.321	(0.010)	0.222
RSVP-1	(P_1)	3.227			(2.319)	(0.010)	0.222
	(P_2)	3.227			(0.877)	(0.010)	0.222
	(P_3)	3.227			5.936	(0.010)	0.222
	(P_4)	3.227			34.911	(0.010)	0.222
GS, GST		3.227	3.411	3.149	0.292	(0.009)	0.221
CS		3.227			0.292	(0.009)	0.221
LS-1, LS-2		3.194			0.180	(0.002)	0.217
GSD Optional							
Secondary		3.227			0.272	(0.007)	0.220
Primary		3.195			0.269	(0.007)	0.218
Subtransmission		3.162			0.267	(0.007)	0.216

Rate Schedules	¢/kWh Fuel Standard	¢/kWh Fuel Peak	¢/kWh Fuel Off-Peak	$/kW Energy Conservation	$/kW Capacity	¢/kWh Environmental
GSD, GSDT, SBF, SBFT						
Secondary	3.227	3.411	3.149	1.17	(0.03)	0.220
Primary	3.195	3.377	3.118	1.15	(0.03)	0.218
Subtransmission	3.162	3.343	3.086	1.14	(0.03)	0.216
IS, IST, SBI						
Primary	3.195	3.377	3.118	0.93	(0.03)	0.214
Subtransmission	3.162	3.343	3.086	0.92	(0.03)	0.212

Continued to Sheet No. 6.021

APPENDIX Q:
RATE SCHEDULE- EVERSOURCE (GREATER BOSTON REGION)

2019 Summary of Eastern Massachusetts Electric Rates for Greater Boston Service Area

Rates Effective: September 1, 2019

The following rates are available to our customers and have been approved by the Massachusetts Department of Public Utilities. In addition to the Delivery Service Charges, to calculate your total bill you will also need to include the Supplier Services charge from your bill (Basic Service or a third-party competitive power supplier).

A1, A5 – Residential (R-1 – M.D.P.U. No. 7)

This rate is available to all domestic uses in a single private dwelling, in an individual apartment or in a residential condominium in which the principal means of heating the premises is not provided by permanently installed electric space heating equipment.

• Customer Charge (per month):	$7.00
• Distribution Energy Charge (per kWh):	$0.06507
• Transition Energy Charge (credit per kWh):	$0.00052
• Transmission Charge (per kWh):	$0.02585
• Revenue Decoupling Charge (credit per kWh):	$0.00057
• Distributed Solar Charge (per kWh):	$0.00088
• Energy Efficiency Charge (per kWh):	$0.01725
• Renewable Energy Charge (per kWh):	$0.00050

A2 – Residential Assistance (R-2 – M.D.P.U. No. 8)

This rate is available to all domestic uses in a single private dwelling, in an individual apartment or in a residential condominium in which the principal means of heating the premises is not provided by permanently installed electric space heating equipment. A Customer will be eligible for this rate upon verification of a Customer's eligibility for the low-income home energy assistance program, or its successor program, or verification of a Customer's receipt of any means-tested public benefit, for which eligibility does not exceed 200 percent of the federal poverty level based on a household's gross income, or other criteria approved by the Department. A 36 percent discount will be applied to the total bill amount.

• Customer Charge (per month):	$7.00
• Distribution Energy Charge (per kWh):	$0.06507
• Transition Energy Charge (credit per kWh):	$0.00052
• Transmission Charge (per kWh):	$0.02585
• Revenue Decoupling Charge (credit per kWh):	$0.00057
• Distributed Solar Charge (per kWh):	$0.00088
• Energy Efficiency Charge (per kWh):	$0.00363
• Renewable Energy Charge (per kWh):	$0.00050

A3 – Residential Space Heating Assistance *(R-4 – M.D.P.U. No. 10)*

This rate is available to all domestic uses in a single private dwelling, in an individual apartment or in a residential condominium in which the principal means of heating the premises is provided by permanently installed electric space heating equipment. A Customer will be eligible for this rate upon verification of a Customer's eligibility for the low-income home energy assistance program, or its successor program, or verification of a Customer's receipt of any means-tested public benefit, for which eligibility does not exceed 200 percent of the federal poverty level based on a household's gross income, or other criteria approved by the Department. A 36 percent discount will be applied to the total bill amount.

• Customer Charge (per month):	$7.00
• Distribution Energy Charge (per kWh):	$0.05687
• Transition Energy Charge (credit per kWh):	$0.00052
• Transmission Charge (per kWh):	$0.02504
• Revenue Decoupling Charge (credit per kWh):	$0.00046
• Distributed Solar Charge (per kWh):	$0.00071
• Energy Efficiency Charge (per kWh):	$0.00363
• Renewable Energy Charge (per kWh):	$0.00050

A4 – Residential Space Heating *(R-3 – M.D.P.U. No. 9)*

This rate is available to all domestic uses in a single private dwelling, in an individual apartment or in a residential condominium in which the principal means of heating the premises is provided by permanently installed electric space heating equipment.

• Customer Charge (per month):	$7.00
• Distribution Energy Charge (per kWh):	$0.05687
• Transition Energy Charge (credit per kWh):	$0.00052
• Transmission Charge (per kWh):	$0.02504
• Revenue Decoupling Charge (credit per kWh):	$0.00046
• Distributed Solar Charge (per kWh):	$0.00071
• Energy Efficiency Charge (per kWh):	$0.01725
• Renewable Energy Charge (per kWh):	$0.00050

APPENDIX R:
RATE SCHEDULE- KANSAS CITY POWER AND LIGHTS

RESIDENTIAL SERVICE
Schedule R

RATE

Single-phase kWh and three-phase kWh will be cumulated for billing under this schedule.

A. RESIDENTIAL GENERAL USE, 1RS1A, 1RSDA, 1RS1B

Customer Charge (Per Month) $11.47

	Summer Season	Winter Season
Energy Charge (Per kWh)		
First 600 kWh per month	$0.13511	$0.12013
Next 400 kWh per month	$0.13511	$0.07396
Over 1000 kWh per month	$0.14916	$0.06561

B. RESIDENTIAL GENERAL USE AND SPACE HEAT - ONE METER, 1RS6A, 1RFEB

When the customer has electric space heating equipment for the residence and the equipment is of a size and design approved by the Company and not connected through a separately metered circuit, the kWh shall be billed as follows:

Customer Charge (Per Month) $11.47

	Summer Season	Winter Season
Energy Charge (Per kWh)		
First 600 kWh per month	$0.13806	$0.09703
Next 400 kWh per month	$0.13806	$0.09703
Over 1000 kWh per month	$0.13806	$0.06300

FILED
Missouri Public
Service Commission
ER-2018-0145; YE-2019-0084

PARALLEL GENERATION CONTRACT SERVICE
Schedule PG (continued)

BILLING AND PAYMENT: (continued)

For electrical energy delivered by the Customer to the Company, the Company shall pay for energy received according to the following:

PAYMENT RATE:

$0.024 per kWh for all kWh received.

The payment amount calculated above shall be reduced $3.50 per month to compensate the Company for the fixed charges on the meter measuring the kilowatt-hours delivered by the Customer to the Company and for the engineering, administrative and accounting costs associated with the delivery of energy by the Customer to the Company.

The payment calculated above is designed to reflect the net value to the Company of energy delivered to the Company by the Customer.

APPENDIX S:
RATE SCHEDULE- PUGET SOUND ENERGY

PUGET SOUND ENERGY

Electric Summary Sheet No. S-4
Effective Date 10/12/2019

SUMMARY OF TOTAL CURRENT PRICES - ELECTRIC
Residential Rate Schedules

Rates in this summary include the effect of all supplemental rate schedules except Schedule 81, Municipal Tax Adjustment, where applicable. In case of discrepancy between data below and the rate schedules, the latter have precedence. All rates shown are subject to adjustment by such other schedules in the company's tariff as may apply.

SCH 7	**RESIDENTIAL SERVICE** Used principally for domestic purposes with service delivered through one meter to a single-family unit. May include limited incidental non-domestic use.

			SINGLE PHASE		THREE PHASE				
	BASIC CHARGE	$	7.49	$	17.99	Per Month	SCH 7	Effective	5/14/2012
	EXPEDITED RATE FILING ADJ	$	-	$	-	Per Month	SCH 141	Effective	12/19/2017
Shown on Billing Statement	TOTAL BASIC CHARGE	$	7.49	$	17.99	Per Month			

			TIER 1 - FIRST 600		TIER 2 - OVER 600				
	ENERGY CHARGE	$	0.087336	$	0.106297	Per kWh	SCH 7	Effective	5/1/2018
	LOW INCOME PROGRAM	$	0.001068	$	0.001068	Per kWh	SCH 129	Effective	10/12/2019
	PROPERTY TAX TRACKER	$	0.003228	$	0.003228	Per kWh	SCH 140	Effective	5/1/2019
	EXPEDITED RATE FILING RATE ADJ	$	0.001425	$	0.001734	Per kWh	SCH 141	Effective	3/1/2019
	EXCESS DEFERRED INCOME TAX *	$	(0.001425)	$	(0.001734)	Per kWh	SCH 141X	Effective	3/1/2019
	TEMPORARY FEDERAL INCOME TAX RATE CREDIT RATE ADJ	$	(0.001271)	$	(0.001271)	Per kWh	SCH 141Y	Effective	5/1/2019
	REVENUE DECOUPLING ADJ MECHANISM (Surcharge)	$	0.000621	$	0.000621	Per kWh	SCH 142	Effective	5/1/2019
Shown on Billing Statement	TOTAL ELECTRICITY CHARGE	$	0.090982	$	0.109943	Per kWh			
Shown on Billing Statement	ENERGY EXCHANGE CREDIT	$	(0.007386)	$	(0.007386)	Per kWh	SCH 194	Effective	10/12/2019
	OTHER ELECTRIC CHARGES & CREDITS								
	POWER COST ADJUSTMENT CLAUSE	$	(0.001098)	$	(0.001098)	Per kWh	SCH 95	Effective	7/1/2019
	FEDERAL WIND POWER CREDIT	$	(0.001913)	$	(0.001913)	Per kWh	SCH 95A	Effective	1/1/2019
	ELECTRIC CONSERVATION SERVICE RIDER	$	0.003905	$	0.003905	Per kWh	SCH 120	Effective	5/1/2019
	MERGER CREDIT	$	-	$	-	Per kWh	SCH 132	Effective	1/1/2019
	RENEWABLE ENERGY CREDIT	$	(0.000073)	$	(0.000073)	Per kWh	SCH 137	Effective	1/1/2019
Shown on Billing Statement	TOTAL OTHER ELEC CHARGES & CREDITS	$	0.000821	$	0.000821	Per kWh			
	TOTAL PER KWH	$	0.084417	$	0.103378	Per kWh			

* Schedule 141X - Protected-Plus Deferred Excess Deferred Income Tax (EDIT) Reversals Rate Adjustment

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