



Home Innovation
RESEARCH LABS™

Cost Implications of Solar Photovoltaic Systems on Single Family Homes

Prepared For

**National Association of Home Builders
1201 15th Street, NW
Washington, DC 20005**

By

**Patti Gunderson, PE
and Elina Thapa**

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DEFINITIONS AND ABBREVIATIONS

| | |
|--------------------|---|
| °F | 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.

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 Data²; 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 Statistics⁴; 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 RSMMeans 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% |
| | Σ 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 Statistics⁵. 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 report⁶ (\$3.70/W_{DC}), the Solar Energy Industries Association (SEIA) U.S. Solar Market Insight⁷ (\$3.00/W_{DC}), and several online PV system pricing tools.^{8, 9, 10}

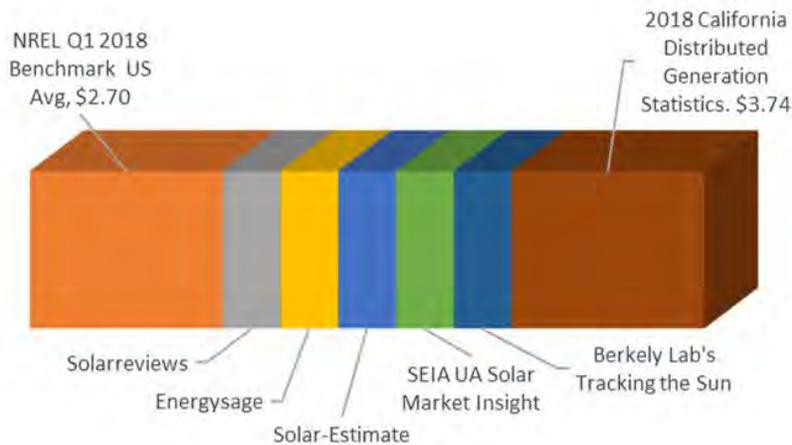


Figure 1. Range of Commonly Referenced PV Pricing Benchmarks, National Average

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 |
|-------------------------|---|---------------|---------------------|---|---------------|---------------------|--|
| | | | | | | | |
| 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)

| Month | State | | | | |
|--------------------------|---------------|---------------|---------------|-----------------|---------------|
| | 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-blkwh?gclid=EAIaIQobChMI5YCHzu3s5AIVjrbICh0xIAasEAKYASABEglfBvD_BwE

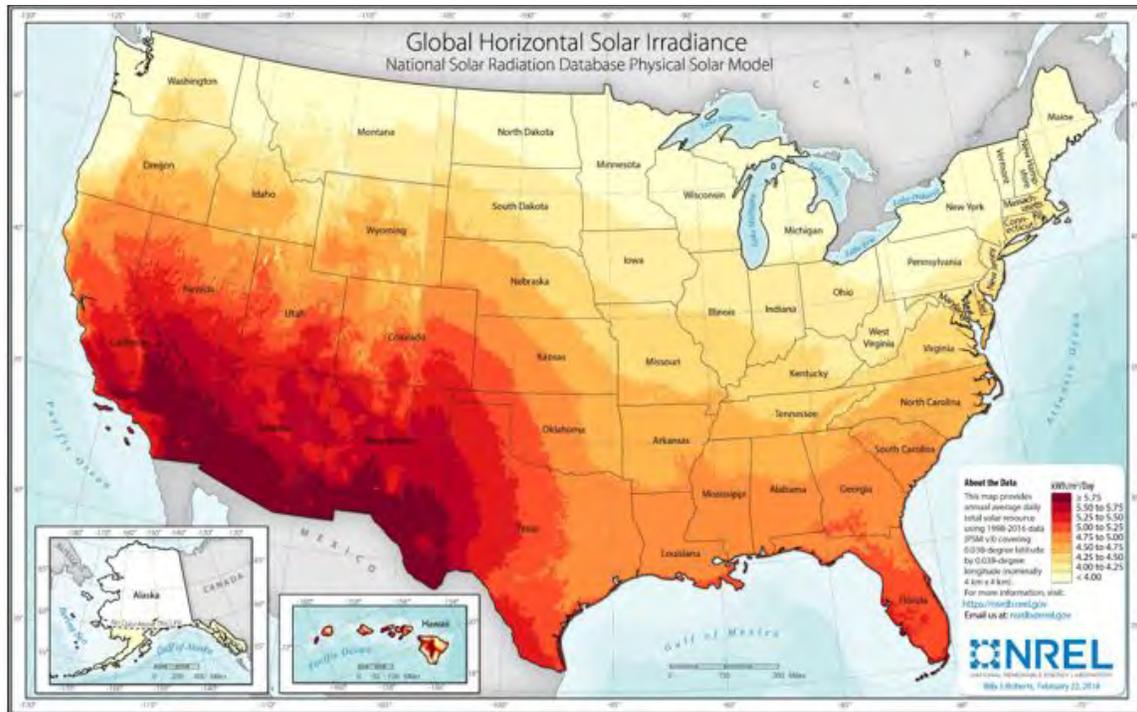


Figure 2. Relative Global Horizontal Solar Irradiance ¹³

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)* | <p>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:</p> $NPV = \sum_{n=0}^N \frac{C_n}{(1 + d_{nominal})^n}$ <p>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).</p> |

*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 | Normalized Payback Period, years | Net Present Value | Simple Payback Period, Years | Normalized 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:

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

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) | | | | |
| | 6% | -1550 | -349 | 593 | 656 | -104 |
| Phoenix | 9% | -1391 | -533 | 140 | 186 | -355 |
| | 12% | -1269 | -614 | -99 | -64 | -476 |
| | 6% | -2084 | -1310 | -1111 | -1551 | -2424 |
| Tampa | 9% | -1789 | -1236 | -1093 | -1408 | -2031 |
| | 12% | -1583 | -1160 | -1051 | -1291 | -1767 |
| | 6% | 2497 | 4555 | 5343 | 4462 | 2386 |
| Boston | 9% | 1490 | 2962 | 3526 | 2896 | 1411 |
| | 12% | 924 | 2049 | 2480 | 1998 | 864 |
| | 6% | -3549 | -2678 | -2321 | -2605 | -3457 |
| Kansas City | 9% | -2827 | -2204 | -1949 | -2152 | -2761 |
| | 12% | -2371 | -1894 | -1699 | -1854 | -2320 |
| | 6% | -4422 | -3528 | -3127 | -3404 | -4245 |
| Seattle | 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 arrangement¹⁴, 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

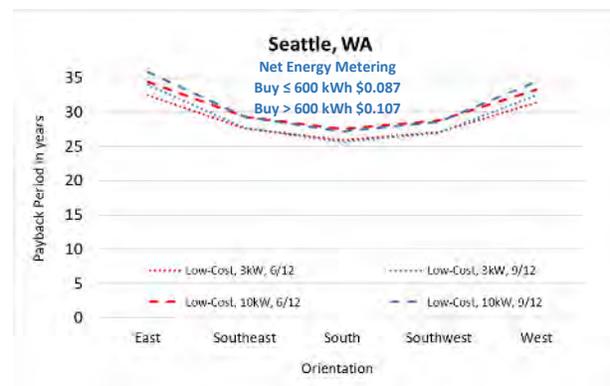
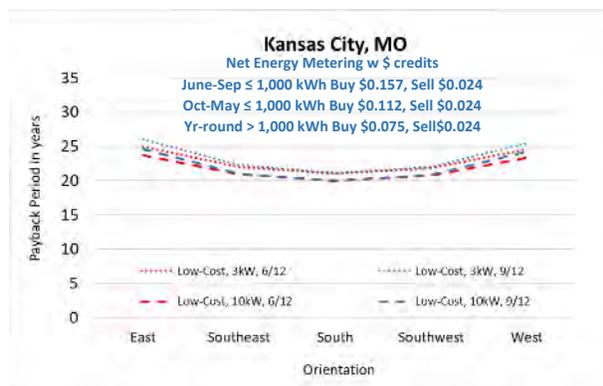
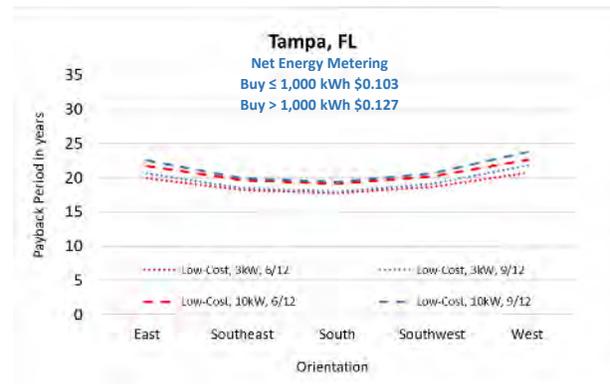
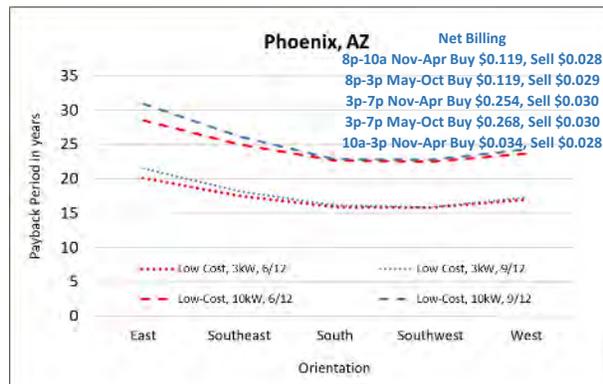
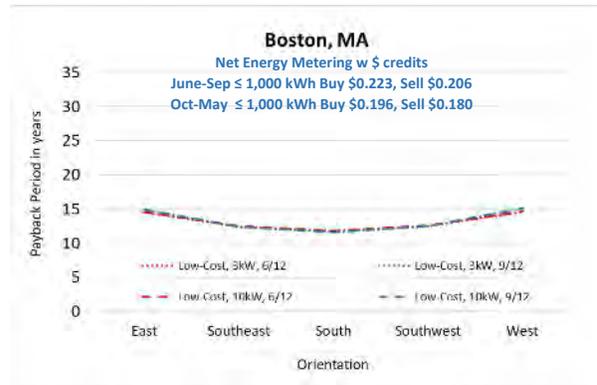
| CITY | Low-Cost System | CZ | LATITUDE | Solar Resource GHI (kWh/m ² /day) | Annual Load, kWh |
|-------------|-----------------|----|----------|--|------------------|
| Phoenix | \$3.17 | 2 | 33.4° N | 5.79 | 16,471 |
| Tampa | \$3.15 | 2 | 27.9° N | 5.22 | 14,273 |
| Boston | \$3.27 | 5 | 42.3° N | 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

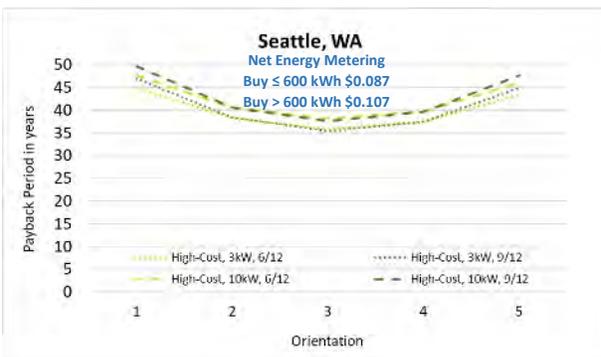
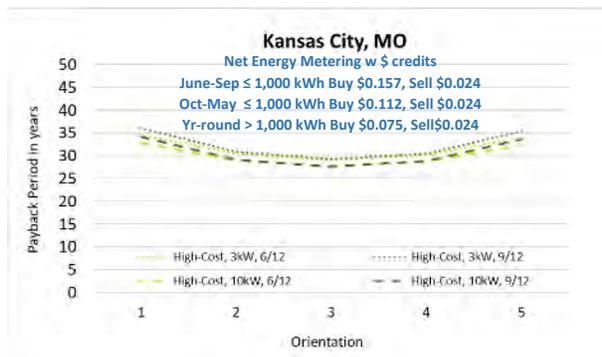
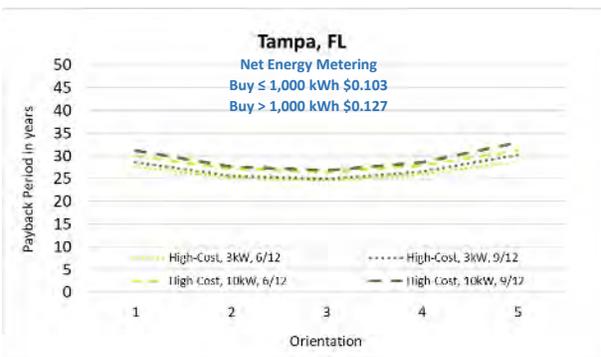
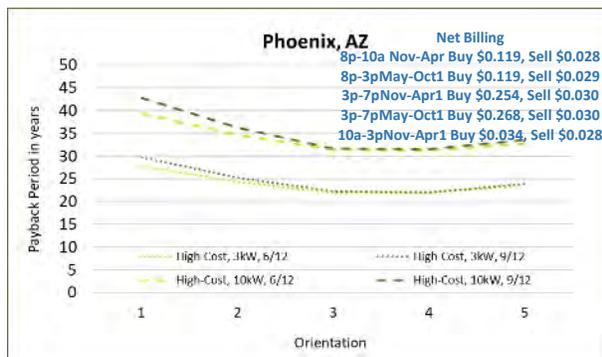
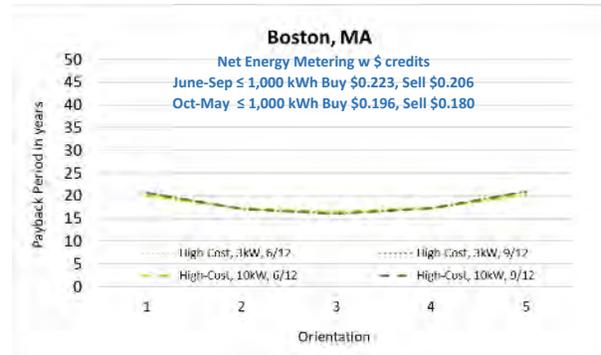
| CITY | High-Cost System | CZ | LATITUDE | Solar Resource GHI (kWh/m ² /day) | Annual Load, kWh |
|-------------|------------------|----|----------|--|------------------|
| Phoenix | \$4.39 | 2 | 33.4° N | 5.79 | 16,471 |
| Tampa | \$4.36 | 2 | 27.9° N | 5.22 | 14,273 |
| Boston | \$4.53 | 5 | 42.3° 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: \$12.81¹⁵; + 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/m ² /day) | Roof Slope | Degrees |
|-------------|----------|-------------------------------|-------------|------------|
| | | | Phoenix, AZ | 33.4484° N |
| | | | 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>

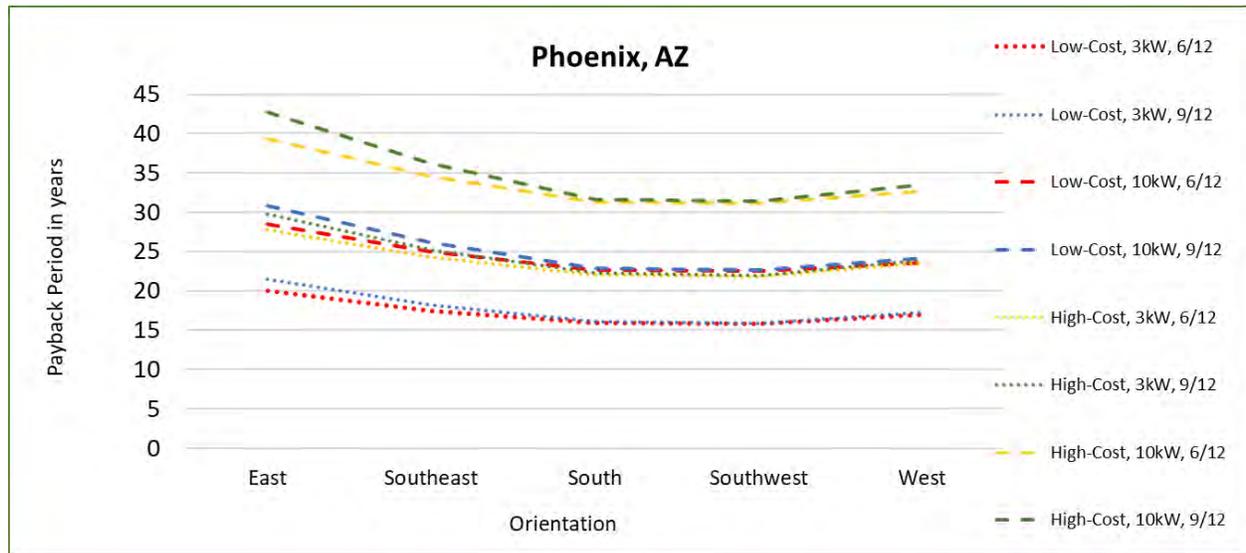
¹⁶ <https://www.aps.com/en/Utility/Regulatory-and-Legal/Rates-Schedules-and-Adjustors>

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) | | | High End Cost (\$4.39/Watt) | | |
| | | | | | Normalized Payback Period, years | Net Present Value, \$ | Simple Payback Period, Years | Normalized Payback Period, years | Net Present Value | 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/m ² /day) | | Roof Slope | | Degrees | | | | | | | | | | | | | | | | | | | |
| Tampa, FL | 27.9506° N | 5.22 | | 6/12 | | 26.57 | | | | | | | | | | | | | | | | | | | |
| | | | | 9/12 | | 36.37 | | | | | | | | | | | | | | | | | | | |
| <p>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.</p> | | | | <p>Among the locations studied, Tampa has...</p> <ul style="list-style-type: none"> • 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 | | | | | | | | | | | | | | | | | | | | | |

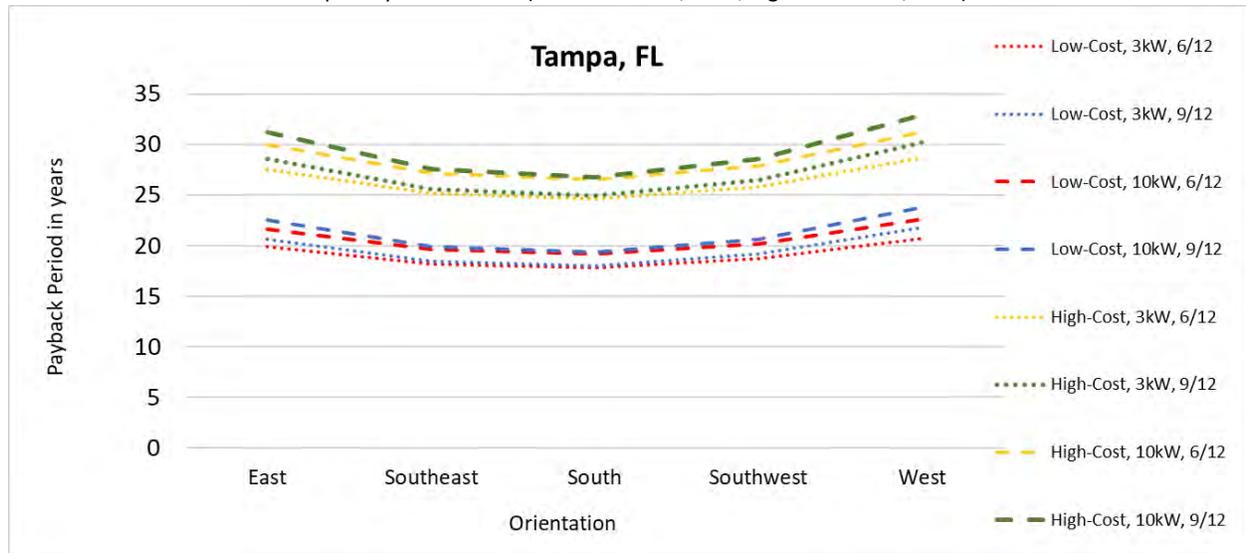
¹⁷ <https://www.tampaelectric.com/files/tariff/tariffsection6.pdf>

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) | | | High End Cost (\$4.36/Watt) | | |
| | | | | | Normalized Payback Period, years | Net Present Value | Simple Payback Period, Years | Normalized Payback Period, years | Net Present Value, \$ | 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) | | Roof Slope | | Degrees | | | | | | | | | | | | | | | | | | | | |
| Boston, MA | 42.3601° N | 4.06 | | 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... | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • 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) | | | | | | | | | | | | | | | | | | | | | | | | | | |

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

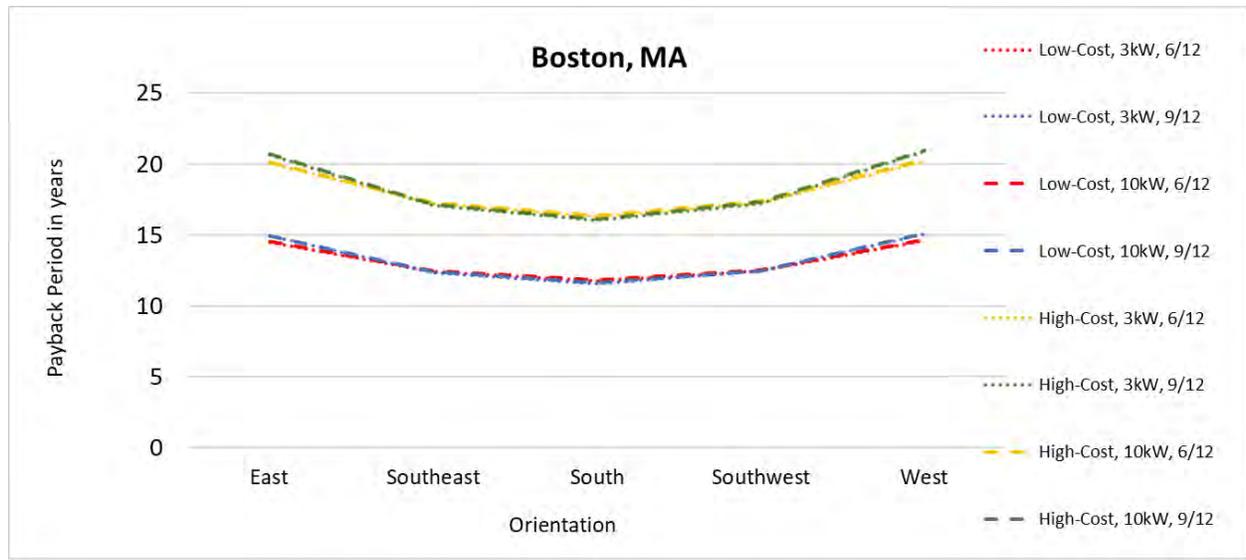
²⁰ https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_38

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) | | | High End Cost (\$4.53/Watt) | | |
| | | | | | Normalized Payback Period, years | Net Present Value | Simple Payback Period, Years | Normalized Payback Period, years | Net Present Value | 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/m ² /day) | Roof Slope | Degrees |
|-----------------|------------|-------------------------------|------------|---------|
| Kansas City, MO | 39.0997° N | 4.38 | 6/12 | 26.57 |
| | | | 9/12 | 36.37 |

| | |
|--|---|
| <p>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.</p> | <p>Among the locations studied, Kansas City has...</p> <ul style="list-style-type: none"> • 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) |
|--|---|

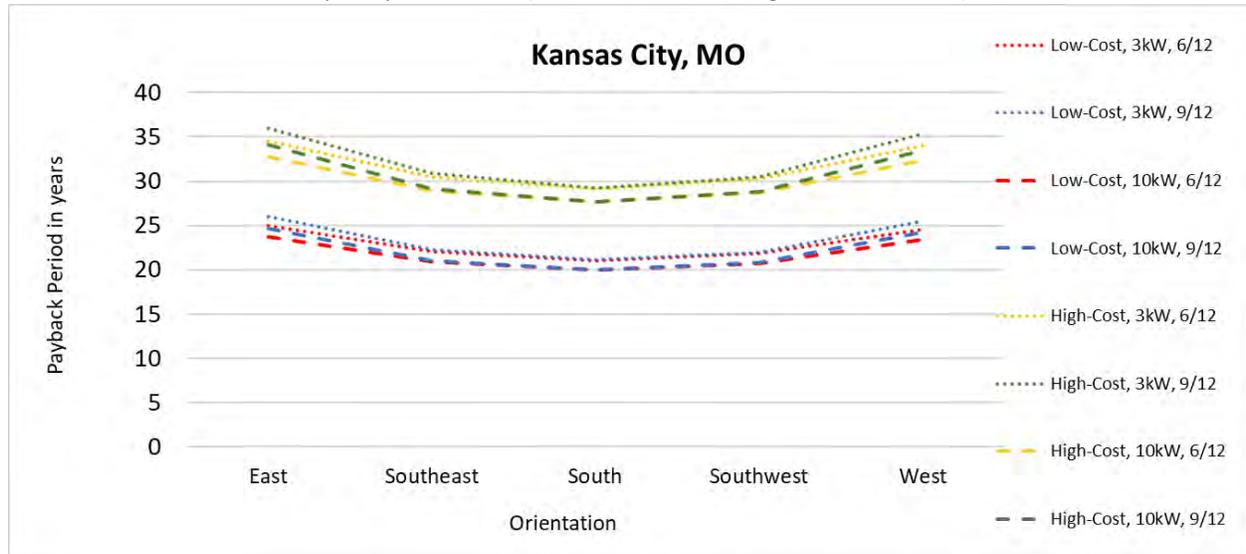
²¹ https://www.evergy.com/-/media/documents/billing/missouri/detailed_tariffs_mo/residential-service-081419.pdf?la=en

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) | | | High End Cost (\$4.46/Watt) | | |
| | | | | | Normalized Payback Period, years | Net Present Value | Simple Payback Period, Years | Normalized Payback Period, years | Net Present Value | 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) | | Roof Slope | | Degrees | | | | | | | | | | | | | | | | | | |
| Seattle, WA | 47.6062° N | 3.47 | | 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... | | | | | | | | | | | | | | | | | |
| | | | | | | | <ul style="list-style-type: none"> • Poor solar resource • Lowest real energy cost • Most generous utility terms (net metering in kWh) | | | | | | | | | | | | | | | | | |

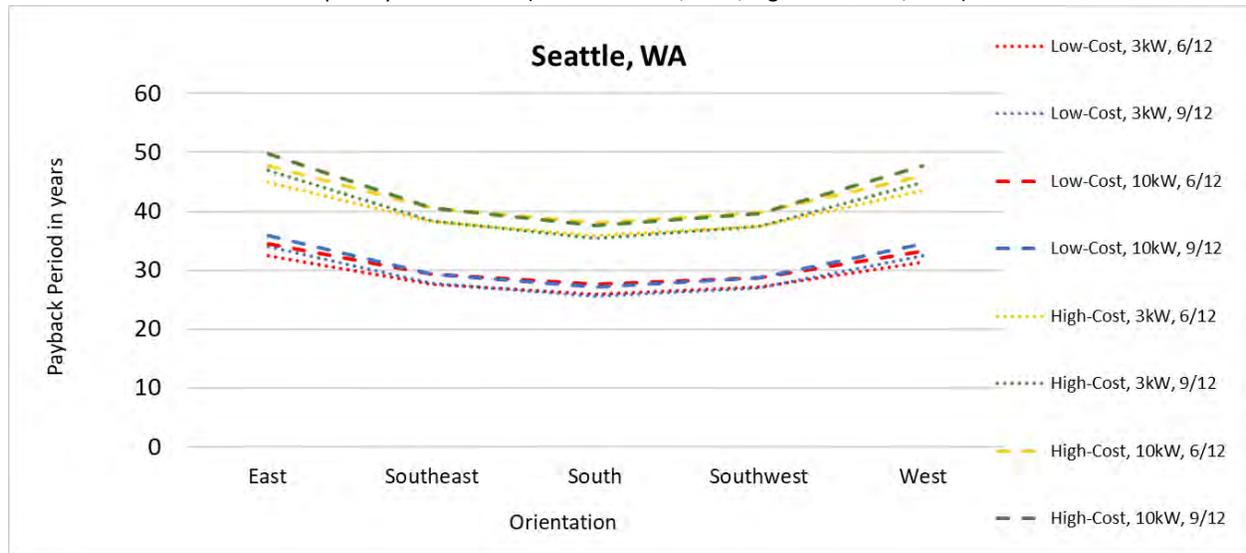
²² <https://www.pse.com/pages/rates/electric-tariffs-and-rules#sort=%40documentdate43883%20descending>

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) | | | High End Cost (\$4.47/Watt) | | |
| | | | | | Normalized Payback Period, years | Net Present Value | Simple Payback Period, Years | Normalized Payback Period, years | Net Present Value | 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.

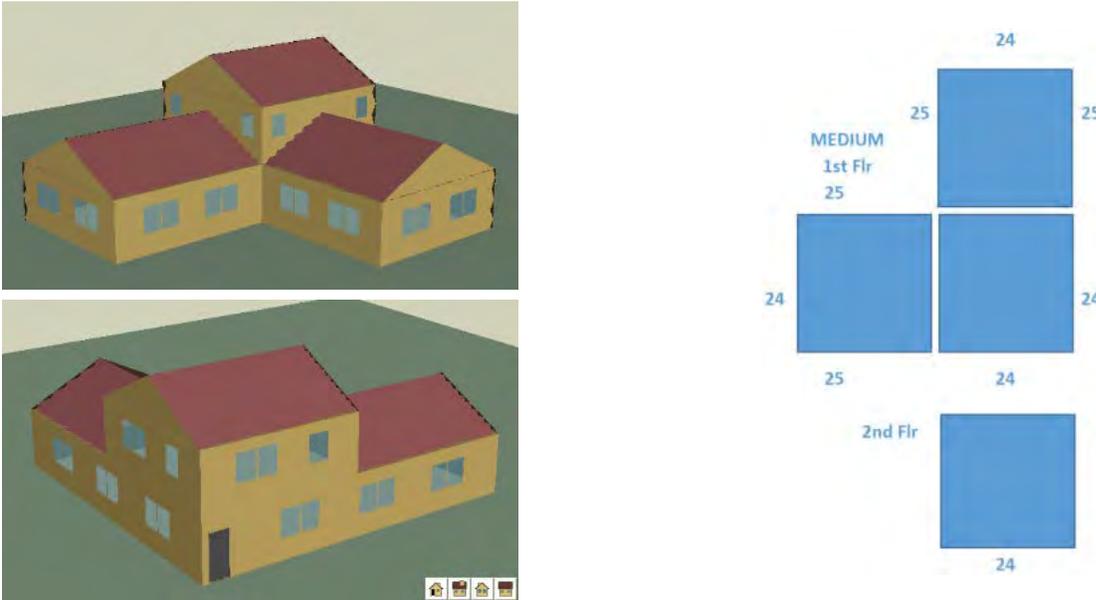


Figure 3. 3-D View (left) and Geometries (right) of the Baseline Building

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.

Weather Data Information

The following information describes the data in the highlighted weather file from the Solar Resource library above. This is the file SAM will use when you click Simulate.

Weather file:

-Header Data from Weather File-

| | | | | |
|-------------|--------------------------------------|-----------|--|---|
| Station ID | <input type="text" value="1010365"/> | Latitude | <input type="text" value="27.93"/> DD | For NSRDB data, the latitude and longitude shown here from the weather file header are the coordinates of the NSRDB grid cell and may be different from the values in the file name, which are the coordinates of the requested location. |
| Data Source | <input type="text" value="NSRDB"/> | Longitude | <input type="text" value="-82.46"/> DD | |
| Elevation | <input type="text" value="3"/> m | Time zone | <input type="text" value="GMT-5"/> | |

-Annual Values Calculated from Weather File Data-

| | | | | |
|----------------------|---|------------------------------|--------------------------------------|------------------------|
| Global horizontal | <input type="text" value="5.22"/> kWh/m ² /day | Average temperature | <input type="text" value="21.5"/> °C | -Optional Data- |
| Direct normal (beam) | <input type="text" value="5.53"/> kWh/m ² /day | Average wind speed | <input type="text" value="2.7"/> m/s | |
| Diffuse horizontal | <input type="text" value="1.76"/> kWh/m ² /day | *NaN indicates missing data. | | |

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

System Performance Degradation

Degradation rate %/year

Applies to the system's total annual AC output.

Battery single year analysis

In this mode, one year of degradation of the battery is modeled, which may not accurately represent battery performance in subsequent years. To consider multiyear degradation, including battery replacement costs, please change to the "Photovoltaic (detailed)" model and select "PV simulation over analysis period".

In Value mode, the degradation rate applies to the system's total annual kWh output for the previous year starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 value. See Help for details.

- 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.”

| | |
|---|---|
| Residential Loan Type | |
| <input type="radio"/> Standard loan | Standard loan interest payments are not tax deductible. |
| <input checked="" type="radio"/> Mortgage | Mortgage interest payments are tax deductible. |

| | | | | |
|------------------------|---------------------------------------|------------------|---|--|
| Loan Parameters | | | | |
| Debt fraction | <input type="text" value="95"/> % | Net capital cost | <input type="text" value="\$ 13,170.00"/> | The weighted average cost of capital (WACC) is displayed for reference. SAM does not use the value for calculations. |
| Loan term | <input type="text" value="30"/> years | Debt | <input type="text" value="\$ 12,511.50"/> | |
| Loan rate | <input type="text" value="4"/> %/year | WACC | <input type="text" value="3.62"/> % | |
| | | | | For a project with no debt, set the debt fraction to zero. |

| | | | |
|----------------------------|---------------------------------------|-----------------------|--|
| Analysis Parameters | | | |
| Analysis period | <input type="text" value="30"/> years | Inflation rate | <input type="text" value="2.5"/> %/year |
| | | Real discount rate | <input type="text" value="6.4"/> %/year |
| | | Nominal discount rate | <input type="text" value="9.06"/> %/year |

| | | | |
|--|--|-----------------------|--|
| Project Tax and Insurance Rates | | - Property Tax | |
| Federal income tax rate | <input type="text" value="14.13"/> %/year | Assessed percentage | <input type="text" value="100"/> % of installed cost |
| State income tax rate | <input type="text" value="3.06"/> %/year | Assessed value | <input type="text" value="\$ 13,170.00"/> |
| Sales tax | <input type="text" value="0"/> % of total direct cost | Annual decline | <input type="text" value="0"/> %/year |
| Insurance rate (annual) | <input type="text" value="0.303"/> % of installed cost | Property tax rate | <input type="text" value="0.59"/> %/year |

| | | | |
|----------------------|--|------------------------------|-----------------------------------|
| Salvage Value | | | |
| Net salvage value | <input type="text" value="0"/> % of installed cost | End of analysis period value | <input type="text" value="\$ 0"/> |

- 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.

System Parameters

System nameplate size kWdc

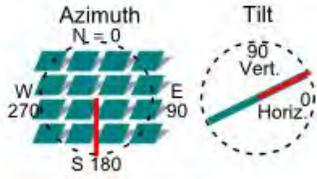
Module type

DC to AC ratio

Rated inverter size kWac

Inverter efficiency %

Orientation



Array type

Tilt degrees

Azimuth degrees

Ground coverage ratio

Losses

| | |
|---|--|
| Soiling <input type="text" value="2"/> % | Connections <input type="text" value="0.5"/> % |
| Shading <input type="text" value="3"/> % | Light-induced degradation <input type="text" value="1.5"/> % |
| Snow <input type="text" value="0"/> % | Nameplate <input type="text" value="1"/> % |
| Mismatch <input type="text" value="2"/> % | Age <input type="text" value="0"/> % |
| Wiring <input type="text" value="2"/> % | Availability <input type="text" value="3"/> % |

Enable user specified losses

User-specified total system losses %

Total system losses %

-Shading

Edit shading losses

-Curtailment and Availability

Curtailment and availability losses reduce the system output to represent system outages or other events.

Constant loss: 0.0 %
Hourly losses: None
Custom periods: None

Battery Bank

Enable battery

Battery capacity kWh

Battery chemistry

Battery power kW

Battery dispatch

6) **System Cost:** Total installed cost per capacity includes all hard and soft 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.

Direct Capital Costs

| | | | | | | |
|---------------------|--------------------------------------|--|---------------------------------------|--|-------------------------------------|---|
| Module | <input type="text" value="1"/> units | <input type="text" value="3.0"/> kWdc/unit | <input type="text" value="3.0"/> kWdc | <input type="text" value="3.27"/> | <input type="text" value="\$/Wdc"/> | <input type="text" value="\$ 9,810.00"/> |
| Inverter | <input type="text" value="1"/> units | <input type="text" value="2.5"/> kWac/unit | <input type="text" value="2.5"/> kWac | <input type="text" value="0.00"/> | <input type="text" value="\$/Wdc"/> | <input type="text" value="\$ 0.00"/> |
| | Battery pack | <input type="text" value="0.0"/> kWh | <input type="text" value="0.00"/> | <input type="text" value="\$/kWh dc"/> | | |
| | Battery power | <input type="text" value="0.0"/> kW | <input type="text" value="0.00"/> | <input type="text" value="\$/kW dc"/> | | <input type="text" value="\$ 0.00"/> |
| | | | \$ | \$/Wdc | | |
| | Balance of system equipment | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> | | | <input type="text" value="\$ 0.00"/> |
| | Installation labor | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> | | | <input type="text" value="\$ 0.00"/> |
| | Installer margin and overhead | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> | | | <input type="text" value="\$ 0.00"/> |
| | | | | | | Subtotal <input type="text" value="\$ 9,810.00"/> |
| -Contingency | | | Contingency | <input type="text" value="0"/> % of subtotal | | <input type="text" value="\$ 0.00"/> |
| | | | | | | Total direct cost <input type="text" value="\$ 9,810.00"/> |

Indirect Capital Costs

| | % of direct cost | \$/Wdc | \$ |
|---|----------------------------------|-----------------------------------|---|
| Permitting and environmental studies | <input type="text" value="0"/> | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> |
| Engineering and developer overhead | <input type="text" value="0"/> | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> |
| Grid interconnection | <input type="text" value="0"/> | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> |
| -Land Costs | | | |
| Land purchase | <input type="text" value="0"/> | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> |
| Land prep. & transmission | <input type="text" value="0"/> | <input type="text" value="0.00"/> | <input type="text" value="0.00"/> |
| -Sales Tax | | | |
| Sales tax basis, percent of direct cost | <input type="text" value="0"/> % | Sales tax rate | <input type="text" value="0.0"/> % |
| | | | <input type="text" value="\$ 0.00"/> |
| | | | Total indirect cost <input type="text" value="\$ 0.00"/> |

Total Installed Cost

| | |
|--|--|
| Total installed cost | <input type="text" value="\$ 9,810.00"/> |
| Total installed cost per capacity | <input type="text" value="\$ 3.27/Wdc"/> |

Operation and Maintenance Costs

| | First year cost | Escalation rate (above inflation) |
|-----------------------------|--|-----------------------------------|
| Fixed annual cost | <input type="text" value="0"/> \$/yr | <input type="text" value="0"/> % |
| Fixed cost by capacity | <input type="text" value="16"/> \$/kW-yr | <input type="text" value="0"/> % |
| Variable cost by generation | <input type="text" value="0"/> \$/MWh | <input type="text" value="0"/> % |

In Value mode, SAM applies both inflation and escalation to the first year cost to calculate out-year costs. In Schedule mode, neither inflation nor escalation applies. See Help for details.

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.

OpenEI U.S. Utility Rate Database
 Download rate structures for electric utility companies included in the OpenEI Utility Rate Database. After downloading a rate structure, compare the inputs below with a copy of the rate sheet to verify that the information is correct.

Search for rates...
[Go to Open EI Utility Rate Database website](#)

Save / Load Rate Data
 Save rate to file... Load rate from file... C:/Users/jfreeman/Desktop/res.csv

Metering and Billing
 Net energy metering
 Net energy metering with \$ credits
 Net billing
 Net billing with carryover to next month
 Buy all / sell all

Sell rate for kWh credits remaining at end of year: 0 \$/kWh
 Use hourly (subhourly) sell rates instead of TOU sell rates
 Hourly (subhourly) sell rates: Edit data... \$/kWh

Fixed Charge
 Fixed monthly charge: 15.12 \$

Annual Escalation
 Electricity bill escalation rate: 0 %/yr

Minimum Charges
 Monthly minimum charge: 0 \$
 Annual minimum charge: 0 \$

In Value mode, enter a rate in real terms because SAM applies both escalation and inflation to the total first-year electricity bill to calculate the annual electricity bill in later years. In Schedule mode, enter rates in nominal terms because inflation does not apply. See Help for details.

Rates for Energy Charges

| Import... | Period | Tier | Max. Usage | Max. Usage Units | Buy (\$/kWh) | Sell (\$/kWh) |
|-----------|--------|------|------------|------------------|--------------|---------------|
| Export... | 1 | 1 | 1000 | kWh | 0.08587 | 0.06587 |
| | 1 | 2 | 1e+38 | kWh | 0.10587 | 0.10587 |

Copy
 Paste
 Number of entries: 2

Weekday

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Day | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 24 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Weekend

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Day | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 24 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

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.

Calculate Load Data ▾

Building Energy Load Profile Estimator

Building Characteristics

Floor area sq ft

Year built

Number of stories

Number of occupants

Energy retrofitted

Occupancy schedule fraction/hr

Electric Appliances

Cooling system Dishwasher

Heating system Washing machine

Range (stove) Dryer

Refrigerator Misc. electric loads

Temperature Settings

Heating setpoint °F

Cooling setpoint °F

Heating setback point °F

Cooling setup point °F

Temperature schedule on/off

Monthly Load Data

| | | | | | |
|-----|----------|-----|-----|----------|-----|
| Jan | 1,162.00 | kWh | Jul | 1,403.00 | kWh |
| Feb | 1,054.00 | kWh | Aug | 1,385.00 | kWh |
| Mar | 987.00 | kWh | Sep | 1,312.00 | kWh |
| Apr | 1,071.00 | kWh | Oct | 1,277.00 | kWh |
| May | 1,228.00 | kWh | Nov | 963.00 | kWh |
| Jun | 1,350.00 | kWh | Dec | 1,080.00 | kWh |

Annual Adjustment

Load growth rate %/yr

In Value mode, the growth rate applies to the previous year's annual kWh load starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 kWh value. See Help for details.

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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 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) | | |
|---------------------------------|-------------------|--------------------------|---------------------------------|--------------|---|--------------------------|------------------------------|---|--------------------------|------------------------------|
| <i>kW</i> | <i>Roof Pitch</i> | <i>Compass Direction</i> | <i>kWh</i> | <i>Value</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> |
| 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) | | |
|---------------------------------|-------------------|--------------------------|---------------------------------|--------------|---|--------------------------|------------------------------|---|--------------------------|------------------------------|
| <i>kW</i> | <i>Roof Pitch</i> | <i>Compass Direction</i> | <i>kWh</i> | <i>Value</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> |
| 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) | | |
|---------------------------------|-------------------|--------------------------|---------------------------------|--------------|---|--------------------------|------------------------------|---|--------------------------|------------------------------|
| <i>kW</i> | <i>Roof Pitch</i> | <i>Compass Direction</i> | <i>kWh</i> | <i>Value</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> |
| 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) | | |
|---------------------------------|-------------------|--------------------------|---------------------------------|--------------|---|--------------------------|------------------------------|---|--------------------------|------------------------------|
| <i>kW</i> | <i>Roof Pitch</i> | <i>Compass Direction</i> | <i>kWh</i> | <i>Value</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> |
| 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) | | |
|---------------------------------|-------------------|--------------------------|---------------------------------|--------------|---|--------------------------|------------------------------|---|--------------------------|------------------------------|
| <i>kW</i> | <i>Roof Pitch</i> | <i>Compass Direction</i> | <i>kWh</i> | <i>Value</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> | <i>Normalized Simple Payback, years</i> | <i>Net Present Value</i> | <i>Simple Payback, years</i> |
| 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.



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 |
|----------------------|---------|---------|



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

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:



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

| | | |
|--------------------|--------|-------------------------|
| 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

ARIZONA PUBLIC SERVICE COMPANY
Phoenix, Arizona
Filed by: Charles A. Miessner
Title: Manager, Regulation and Pricing

A.C.C. No. 5915
Rate Schedule TOU-E
Original
Effective: August 19, 2017



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:



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

| | | | |
|--------------|--|----------|---------|
| 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.**



**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 | | | ¢/kWh | ¢/kWh | ¢/kWh |
|--------------------------|----------|-------|----------|---------------------|----------|---------------|
| | Fuel | | Off-Peak | Energy Conservation | Capacity | Environmental |
| | Standard | Peak | Off-Peak | | | |
| 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 | | | \$/kW | \$/kW | ¢/kWh |
| | Fuel | | Off-Peak | Energy Conservation | Capacity | Environmental |
| | Standard | Peak | Off-Peak | | | |
| 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**

KANSAS CITY POWER AND LIGHT COMPANY

P.S.C. MO. No. 7 Tenth Revised Sheet No. 5A
 Canceling P.S.C. MO. No. 7 Ninth Revised Sheet No. 5A
 For Missouri Retail Service Area

| |
|---|
| 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 | |
| | <u>Summer Season</u> | <u>Winter Season</u> |
| 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 | |
| | <u>Summer Season</u> | <u>Winter Season</u> |
| 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

Issued: November 6, 2018
 Issued by: Darrin R. Ives, Vice President

Effective: December 6, 2018
 1200 Main, Kansas City, MO 64015

KANSAS CITY POWER & LIGHT COMPANY

P.S.C. MO. No. 7 Twelfth Original Sheet No. 31A

Revised

Cancelling P.S.C. MO. No. 7 Eleventh Original Sheet No. 31A

Revised

For Missouri Retail Service Area

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:

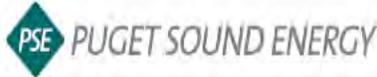
PAYMENT RATE:

\$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**



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 | \$ 0.108297 | 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



Home Innovation
RESEARCH LABS™