# Impacts of Regional Electricity Prices and Building Type on the Economics of Commercial Photovoltaic Systems

Sean Ong, Clinton Campbell, and Nathan Clark

**NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

**Technical Report**
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Prepared under Task No. SM12.1031

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# Executive Summary

Business owners often have a choice between multiple electricity rate options. For businesses with photovoltaic (PV) installations, choosing the right rate is essential to maximize the value of PV generation. The complex interaction between PV generation, building load, and rate structure makes determining the best rate a challenging task. We evaluated 207 rate structures across 77 locations and 16 commercial building types and identified the impacts of regional electricity prices and building type on the economics of solar PV systems. Results for expected solar value that result from bill savings are reported for all locations, building types, and rate structures evaluated. Aggregated results are also reported, showing general trends across various impact categories. Key findings include:

- **Regional electricity price differences are more important than building type when considering PV economics.** On average, system economic performance varies 30% by building type. Buildings with relatively large rooftop area and lower energy consumption tend to yield higher-than-average solar value. Regionally, PV system economics vary by a factor of 10, with the most economically attractive locations having the highest average electricity prices.
- **The best electricity rate for a business depends on the amount of PV capacity installed relative to the building's electricity load.** The rate structure that minimizes the business's electricity expenses prior to a PV installation still remains the best rate after a PV system is installed, as long as the system is small compared to the business's electric load. Other rates provide greater value than the initial rate for larger PV system sizes (see Figure ES-1 for an example).
- **Rate structure elements impact PV economic performance, with energy-only rates being most favorable.** On average, energy-only rates were found to increase solar value by 13%, versus rates with demand charges. Flat energy-only rates were found to be the most favorable, while rates that combined demand charges with tiered rates were found to be the least favorable.

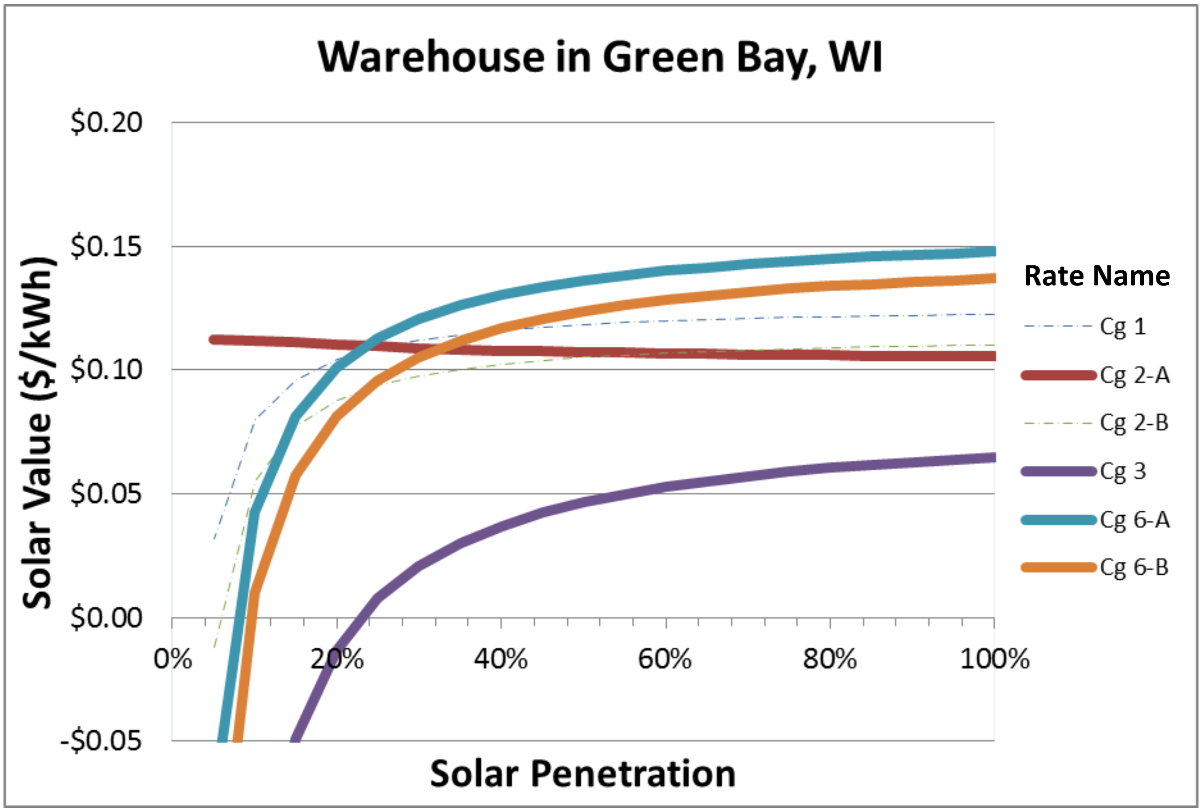


**Figure ES-1. Value of PV generation under various rate structures and penetration levels for warehouses in the Wisconsin Electric Power territory**

Notes: Additional details for each rate type is provided in Appendix A. Dashed lines represent non-applicable rates for this building type.

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# 1 Introduction

Businesses are increasingly considering solar technologies as a way to help offset a portion of their annual energy expenditures. Many commercial buildings have large, flat roofs that could allow for solar photovoltaic (PV) systems capable of generating a significant portion of their annual electricity needs. However, the value of this generation is highly dependent on the business's electricity rate. Utilities often offer a choice between multiple rate options. Understanding conditions for optimal solar value requires an analysis of the interaction between the building electric load, the amount of PV generation, and rate structure. The availability of high resolution data (i.e., hourly or sub-hourly resolution) is essential when determining the impacts of time-of-use (TOU) rates and demand charges. These considerations may present a challenging task for businesses that are trying to determine whether or not solar makes economic sense for their building. In this study, we evaluate the impacts of regional electricity prices and building type on the economics of solar PV systems.

A variety of analyses on the impacts of rate structures on the economics of PV systems have been conducted, including the evaluation of the residential sector (Darghouth et al. 2010) and commercial sector (Wiser et al. 2007) in California. Commercial rate structures have also been evaluated for specific building categories, such as office buildings (Ong et al. 2010) and schools (Ong and Denholm 2011). This report adds to the literature by providing a national-scale evaluation of the impacts of commercial rate structures across a variety of building categories.

In this study, 207 rate structures from 52 electric utilities are evaluated. These rate structures were used to assess solar value and annual savings for 16 different building types. Rate impacts are dependent on individual building load profiles, which vary from one location to another. PV performance trends and relative bill savings are reported across all rates, building types, and locations evaluated. These results are not intended to represent any specific customer. Businesses considering a solar installation should evaluate their facility's unique load profile and use this report as a guide to analyze the potential impacts of a PV system.

# 2 Data and Methodology

## 2.1 Data and Methodology Overview

The complex interaction between building load, solar production, and electricity rate structure requires a model that can simultaneously process all elements involved. The System Advisor Model (Section 2.5) is used to generate solar production and bill savings results from a variety of inputs, including: hourly building load data (Section 2.2), utility rate data (Section 2.3), and meteorological data (Section 2.4). The following sections provide details on the data and methodology used in this analysis.

## 2.2 Load Data

Building load datasets are important components in any rate structure analysis that includes demand charges and tiered rates. Demand charges (defined in Section 2.3) are usually based on the peak monthly power demand of a building; consequently, quantifying the demand reduction value of a PV system requires a load profile. Load profiles are also required when evaluating tiered rates and demand charges, where rates vary depending on monthly energy usage. This analysis uses load profile data for 16 building categories from the U.S. Department of Energy (DOE) commercial reference building models (Deru et al. 2011), which were simulated using the EnergyPlus simulation software.[1] All loads and buildings for the benchmark models were simulated under typical meteorological year 3 (TMY3) conditions. TMY3 is a dataset of the National Solar Radiation Database (Wilcox 2007; Wilcox and Marion 2008). For consistency, TMY3 conditions were also used when simulating PV performance. Section 2.4 contains more information about the TMY3 weather data. Load data were simulated for 77 locations throughout the United States. Locations were selected from the largest utilities in each state and chosen to represent all climate zones in the contiguous United States. Figure 1 shows the locations analyzed and official climate zones recognized by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). Sixteen building categories were simulated for each of the 77 locations, resulting in 1,232 unique load profiles used in this analysis. Table 1 summarizes each building type used in this study.

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[1] The reference buildings used in this study represent are based on current building codes and are not intended to represent older building construction. For more information on the EnergyPlus model, see http://apps1.eere.energy.gov/buildings/energyplus/.

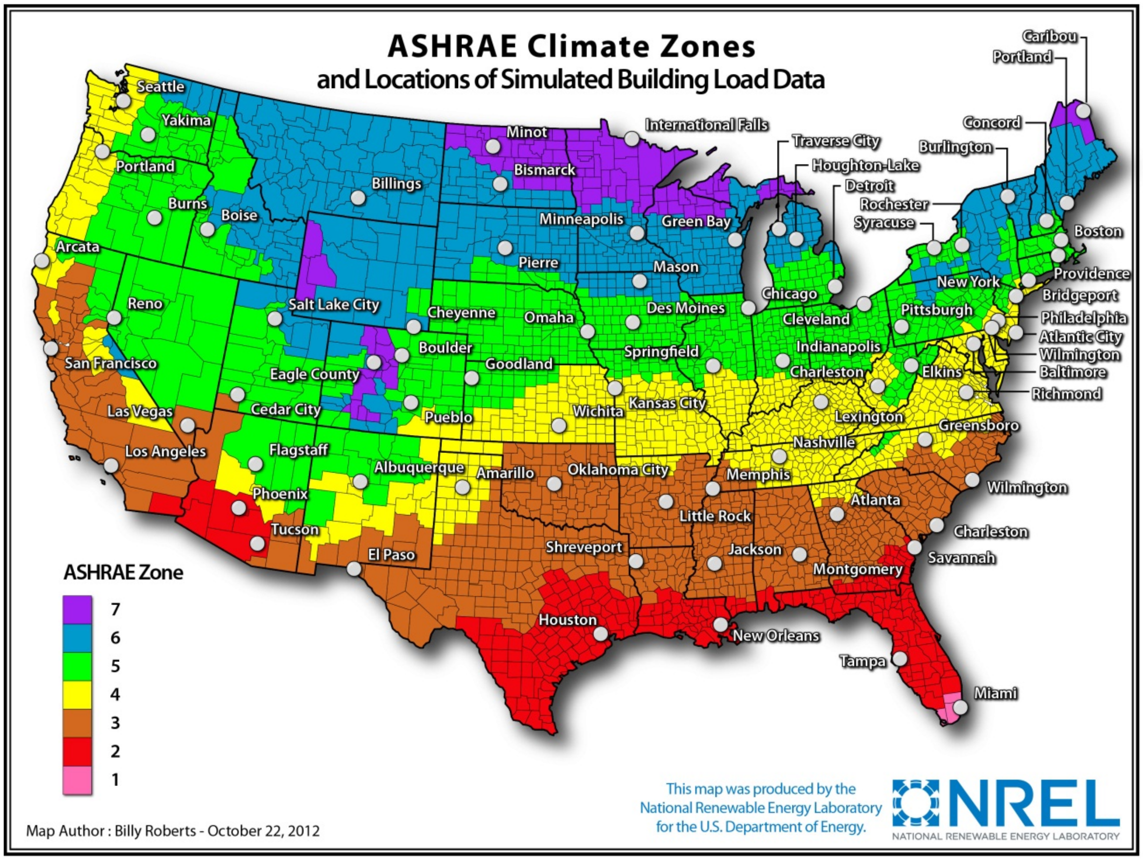


**Figure 1. Locations of simulated building load data, shown within ASHRAE climate zones**

**Table 1. DOE Reference Buildings With Average Energy Consumption and Peak Power**

| Building Type | Floor Area ($ft^2$) | Number of Floors | Annual Energy (MWh) | Peak Power (kW) |
|---|---|---|---|---|
| Full-Service Restaurant | 5,500 | 1 | 322 | 68 |
| Hospital | 241,351 | 5 | 9,287 | 1,510 |
| Large Hotel | 122,120 | 6 | 2,842 | 553 |
| Large Office | 498,588 | 12 | 6,244 | 1,580 |
| Medium Office | 53,628 | 3 | 742 | 318 |
| Mid-Rise Apartment | 33,740 | 4 | 242 | 67 |
| Outpatient | 40,946 | 3 | 1,388 | 321 |
| Primary School | 73,960 | 1 | 888 | 328 |
| Quick-Service Restaurant | 2,500 | 1 | 194 | 39 |
| Secondary School | 210,887 | 2 | 3,193 | 1,178 |
| Small Hotel | 43,200 | 4 | 600 | 133 |
| Small Office | 5,500 | 1 | 66 | 19 |
| Standalone Retail | 24,962 | 1 | 327 | 104 |
| Strip Mall | 22,500 | 1 | 297 | 93 |
| Supermarket | 45,000 | 1 | 1,687 | 367 |
| Warehouse | 52,045 | 1 | 269 | 96 |

The simulated building data includes aggregated hourly load profiles for all electrical loads associated with each building and includes smaller loads such as plug loads. The total hourly electrical load of each building was entered into the System Advisor Model (SAM).[2] See Section 2.5 for SAM details. Figure 2 and Figure 3 show select examples for simulated hourly office load data during the last week of March and the second week of July, respectively.

[2] Demand charges are usually measured and billed according to 15- or 30-minute time increments. The lack of 15-minute data resolution for this analysis may present an overestimation of a PV system's ability to offset demand charges. This could occur if the hourly data masks or smoothes sub-hourly spikes and dips in demand and production.

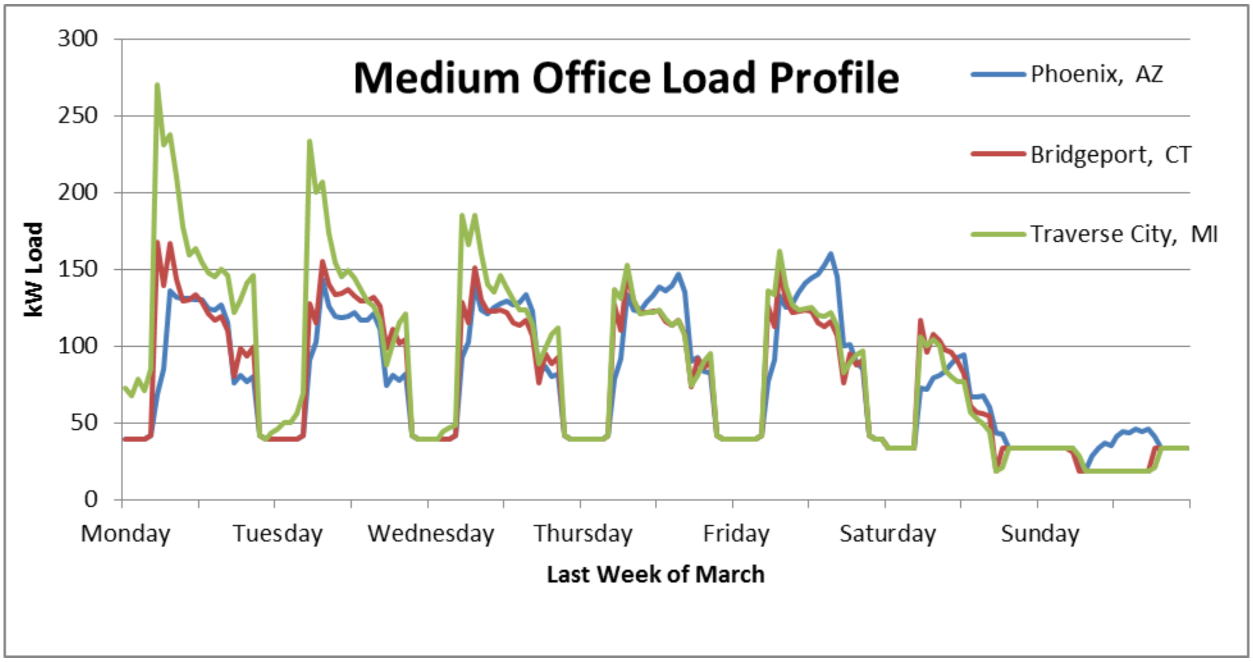


**Figure 2. Simulated hourly load data for medium-sized office buildings during the last week of March**

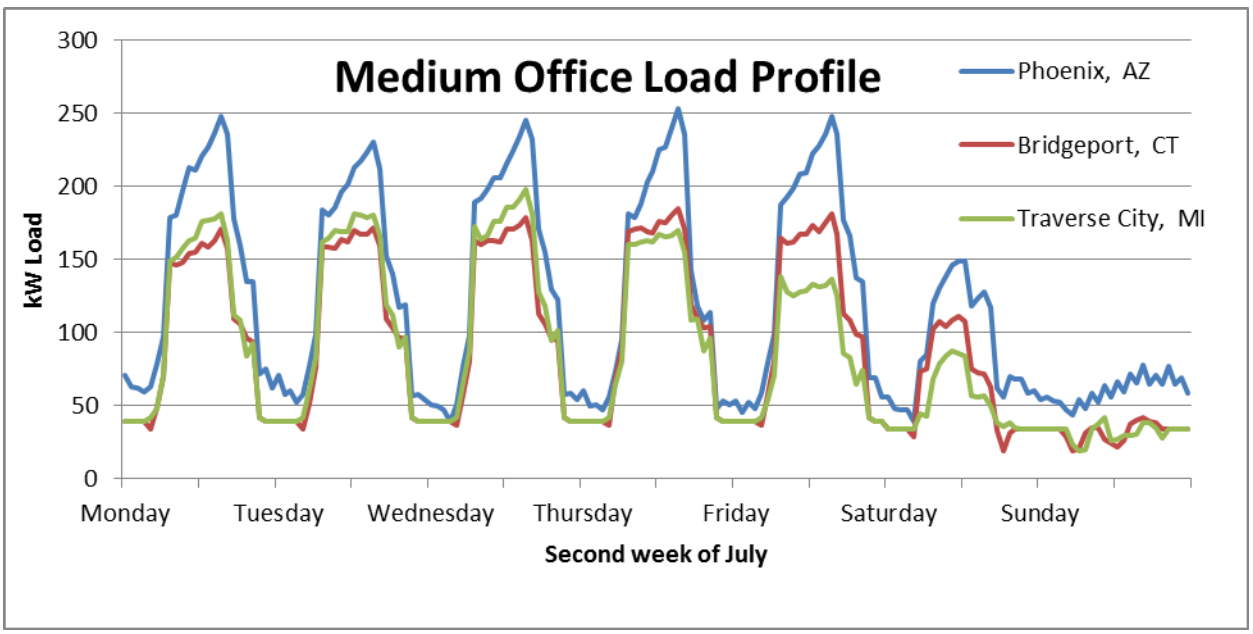


**Figure 3. Simualted hourly load data for medium-sized office buildings during the second week of July**

## 2.3 Rate Data

A total of 207 rates from 52 utility companies were evaluated.[3] These rates were obtained from the online Utility Rate Database (URDB) on the OpenEI platform[4] and from utility tariff sheets. This study assumes that PV energy production is compensated at the retail electricity rate for all energy produced, up to 100% of the building's annual electricity usage.[5] The utilities offer various commercial rate structures for different load sizes and types. In this analysis, we consider standard rates and optional rates. A standard rate refers to a rate that a building would be subject to by default, based on applicability requirements such as peak demand, voltage requirements, or energy consumption. An optional rate refers to a rate that customers may choose in lieu of the standard rate option. Smaller loads typically have more rate choices than larger loads because smaller users may sometimes choose to be on rates designed and made mandatory for larger loads. In some cases, larger facilities with solar installations have the option to use rates designed for smaller facilities. Eligibility criteria were obtained for each rate evaluated and were considered when calculating utility bills for each building type. Figure 4 illustrates the eligibility range for 22 utility rates in California, based on building demand in kilowatts (kW). Some rates are not applicable to all buildings, and they were not considered in the rate and cost impact calculations, though they were still analyzed for reference purposes. For a complete list of utility rates evaluated and their respective eligibility requirements, see Appendix A.

[3] Although we evaluated 77 unique locations for the building load profiles, there are instances when two or more locations are served by the same utility company. Each of the 77 locations is served by one of the 52 utilities.

[4] Open Energy Information (OpenEI) is a knowledge-sharing online community dedicated to connecting people with the latest information and data on energy resources from around the world (http://www.OpenEI.org). OpenEI was created in partnership with the DOE and federal laboratories across the nation. OpenEI's URDB (http://en.openei.org/wiki/Gateway:Utilities) contains downloadable rate structure information from electric utilities around the United States.

[5] This arrangement is also known as net metering, which may not be available in all states or utilities. For a complete list of utilities participating in net-metering arrangements, see the Database of State Incentives for Renewables and Efficiency (DSIRE) (http://www.dsireusa.org/). In this analysis, PV production never exceeds 100% of the building's annual electricity usage.

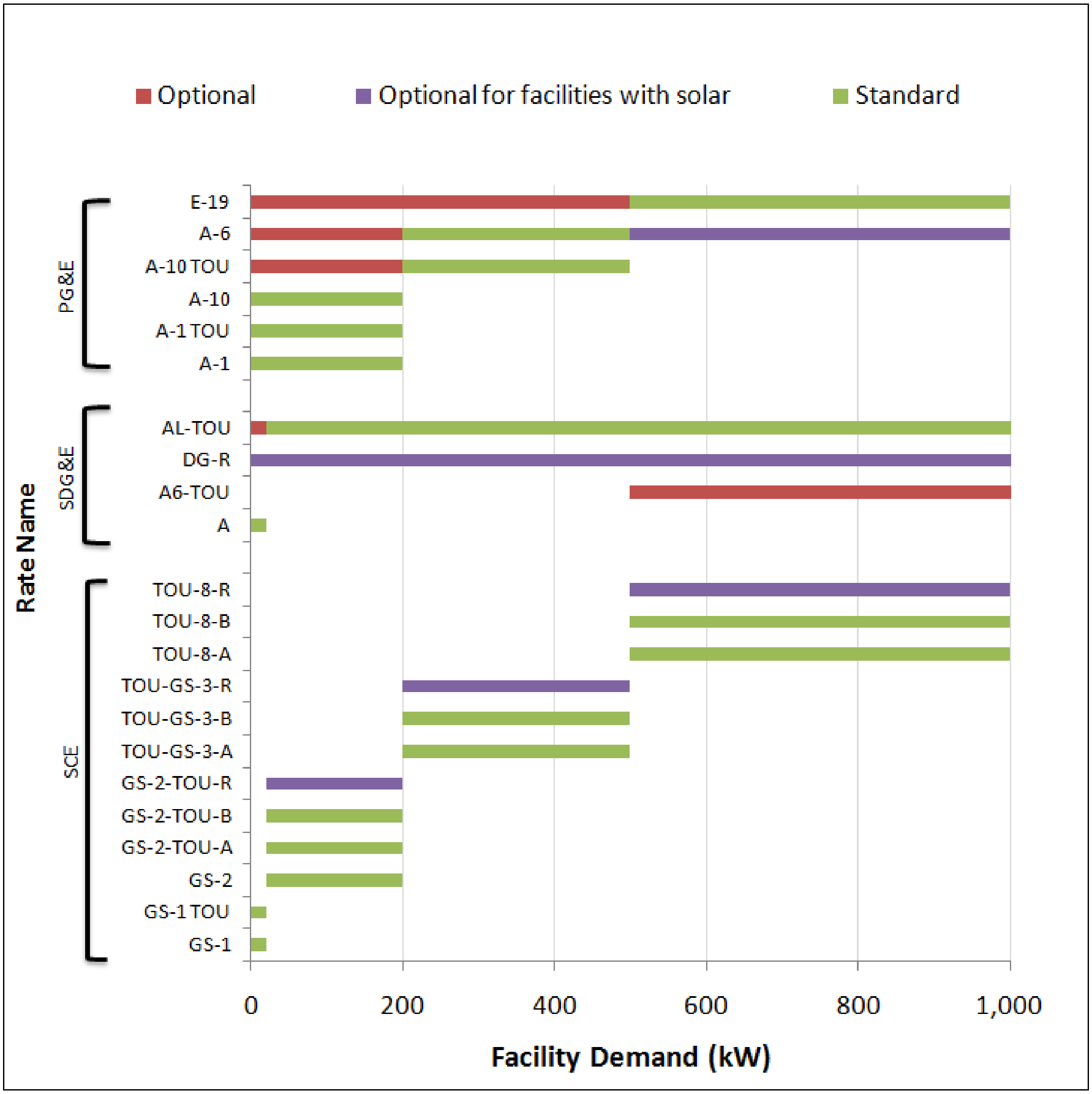


**Figure 4. Example of applicability of electricity rates for commercial facilities in three utility service territories in California**

Various utility rate elements are used throughout the United States. The most common rate elements (Ong et al. 2010) include the following:

- **Customer Charge**. A fixed monthly charge that is independent of energy use. Customer charges typically range from $10 for small businesses to over $1,000 for large facilities.
- **Energy Charges**. Energy charges are rates based on energy consumption, usually in dollars per kilowatt-hour or cents per kilowatt-hour.

- **Demand charges**. Normally included with energy charges in applicable rate structures, demand charges charge customers for their peak power (kW) usage. Demand charges can also be fixed or vary by season or hour.
- **Flat rates**. Fixed cost of electricity that does not vary except for fuel cost adjustments and other fees.
- **Seasonal rates**. Rates that vary by season. A typical seasonal rate structure has a lower rate for winter months and a higher rate for summer months.
- **Time-of-use rates**. TOU or time-of-day rate structures usually vary 2–4 times a day. A typical TOU rate has a lower cost at night, a higher cost during the late afternoon, and an intermediate cost during the mornings and evenings. The term "on-peak" or "peak" is generally used to describe hours with higher prices, while "off-peak" is used to describe hours with lower prices.
- **Tiered or block rates**. Tiered rates typically refer to rates that increase with increasing electricity usage, while block rates typically refer to rates that decrease with increasing electricity usage. Block rates are most common in the form of energy charges; however, tiered demand charges are also used.

Utilities may combine multiple rate elements within a single rate structure. Demand charges are typically combined with other rate elements for commercial tariffs. Table 2 provides a summary of rate elements from the rates used in this report. For a complete list of utility rates evaluated and their respective rate type, see Appendix A.

**Table 2. Summary of Rate Types Used in This Study**

| Rate Type | Flat/Seasonal | Demand Charge | TOU | Tiered |
|---|---|---|---|---|
| Number of Rates[a] | 97 | 141 | 55 | 61 |

[a] Due to combinations of various rate elements, the sum of rates across all categories is greater than the number of rates we evaluated (207).

## 2.4 Solar Resource Data

The PV production data used in this analysis were simulated using the TMY3 dataset of the National Solar Radiation Database (Wilcox and Marion 2008). The TMY3 dataset is intended to represent a typical year's weather and solar resource patterns, though the dataset does not consist of an actual representative year. Rather, TMY3 was created by combining data from multiple years.[6] The meteorological dataset was used as an input for SAM, which simulated hourly PV production for use in the financial calculations.

## 2.5 System Advisor Model and Technical Calculations

Developed by the National Renewable Energy Laboratory (NREL) in collaboration with Sandia National Laboratories and DOE, SAM is a performance and economic model designed to facilitate decision making and analysis for renewable energy projects (Gilman and Dobos 2012).

[6] For example, the month of January may be from one year (e.g., 1989) while February may be from another year (e.g., 1994). Each TMY3 file may contain data from up to 12 different years. Data was intentionally selected to be representative of typical meteorological conditions.

The TMY3 meteorological data was provided as an input for SAM, which uses a performance model and user-defined assumptions to simulate hourly PV generation data. The following assumptions were used when generating the PV performance data:

- Tilt of 15 degrees
- South facing (180-degree azimuth)
- A derate factor of 85%
- Annual degradation of 0.5%.

In addition to the meteorological data, hourly building load data and utility rate data were given as inputs for SAM. A rooftop PV system was simulated for various penetration levels ranging from 0% (no PV system) to 100% (PV system generates the same amount of energy as each building's annual electrical energy consumption[7]) in increments of 5%. PV penetration is defined as the percentage of a facility's annual electrical energy consumption that is met by a PV system. The value of the PV system's generation under various penetration levels and rate structures was evaluated by comparing the buildings' annual electricity costs both with and without the PV system in each scenario. Any resulting difference from the comparison was attributed to the PV system.

## 2.6 Bill Savings and Solar Value Calculations

Solar value provides insight into the value of the energy the system is generating. Solar value is calculated as follows:

$$Solar\ value\ \left(\$/_{kWh}\right) = \frac{Bill\ reduction}{Solar\ generation}$$

Figure 5 illustrates the value of a rooftop PV system on a secondary school building using Pacific Gas & Electric (PG&E) rates under different penetration levels. Rate A-6 yields the greatest solar value at $0.23/kWh, far above the other rate structures. Rate A-6 is a very expensive rate, with summer afternoon prices approaching $0.45/kWh. Although this gives high value to a PV system, a school switching to this rate from a less-expensive rate experiences an increase in total electricity cost, causing net losses rather than savings. Evaluating a rate structure in isolation without considering net bill impacts or other rate structure options is insufficient when conducting a rate analysis.

[7] Although the PV system generates the equivalent of 100% of the building's annual electricity consumption, there will be times that the PV system exports energy to the grid (afternoons) and times that the building imports energy (nights). Existing net-metering policies typically allow excess generation to be credited toward the following month's bill, effectively allowing the generation to be compensated, up to 100% of annual consumption, at retail rates.

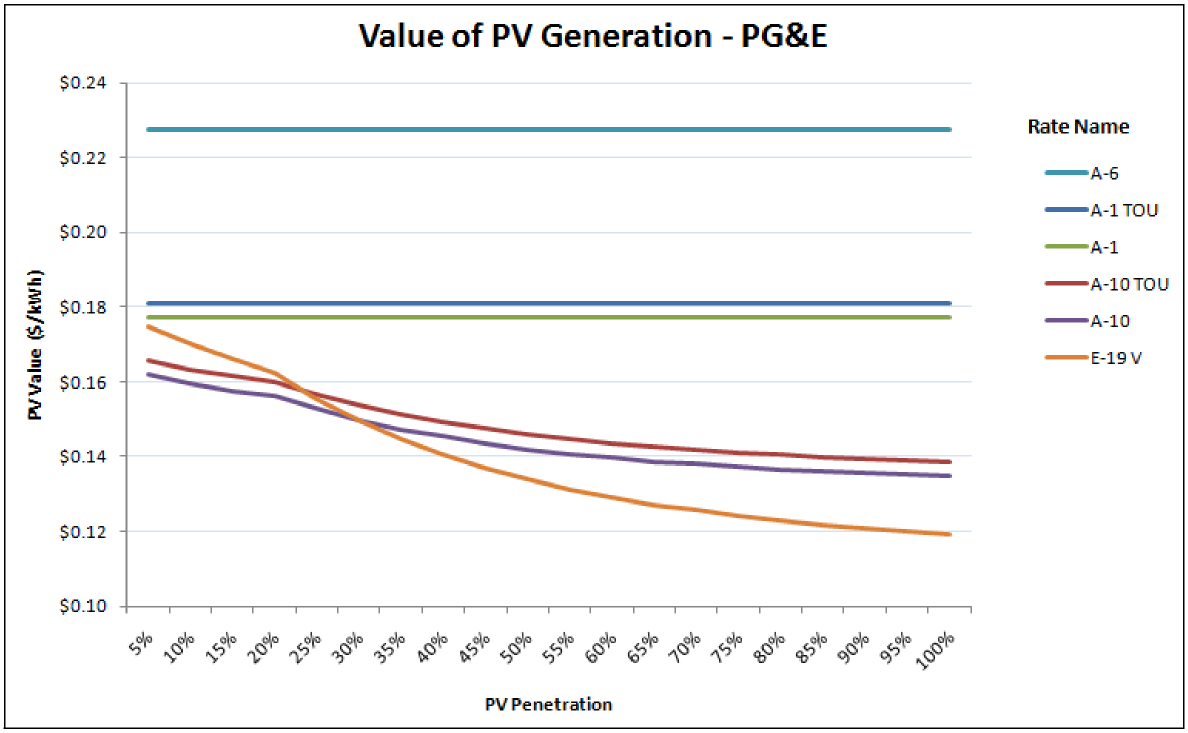


**Figure 5. Value of PV generation under various rate structures and penetration levels for a school in the PG&E service territory**

In order to accurately assess the value of PV under each rate structure, it is necessary to compare the building's annual electricity costs without PV using the least-cost rate. The least-cost rate is the rate that minimizes annual electricity expense. This allows for the proper assessment of solar value in relation to the building's lowest cost option prior to the PV installation. This calculation can be expressed as the following equation:

$$Net\ solar\ value\ \left({}^{\$}/_{kWh}\right) = \frac{Lowest\ bill\ without\ solar - New\ rate\ bill\ with\ solar}{Solar\ generation}$$

Figure 6 shows how the solar value chart changes once we employ the net solar value calculation method. This is a significant change from the previous chart, showing that rate A-6 is no longer the most attractive rate at all penetration levels. Many rates yield a negative value when PV penetration is small. This is because switching to these rates from rate A-10 (the best or least-expensive rate option without PV) increases the building's annual energy cost, despite having a small rooftop PV system. Though the PV system is still providing value to the building, it is not enough to overcome the increase in cost associated with switching to a more expensive rate. The result is a net annual loss for the building. At higher solar penetrations, the increase in solar value (under rates with high energy charges and high daytime rates) is enough to offset the cost increases from switching rates, yielding a net savings. All subsequent mentions of solar value or PV value in this paper refer to the *net solar value* metric above.

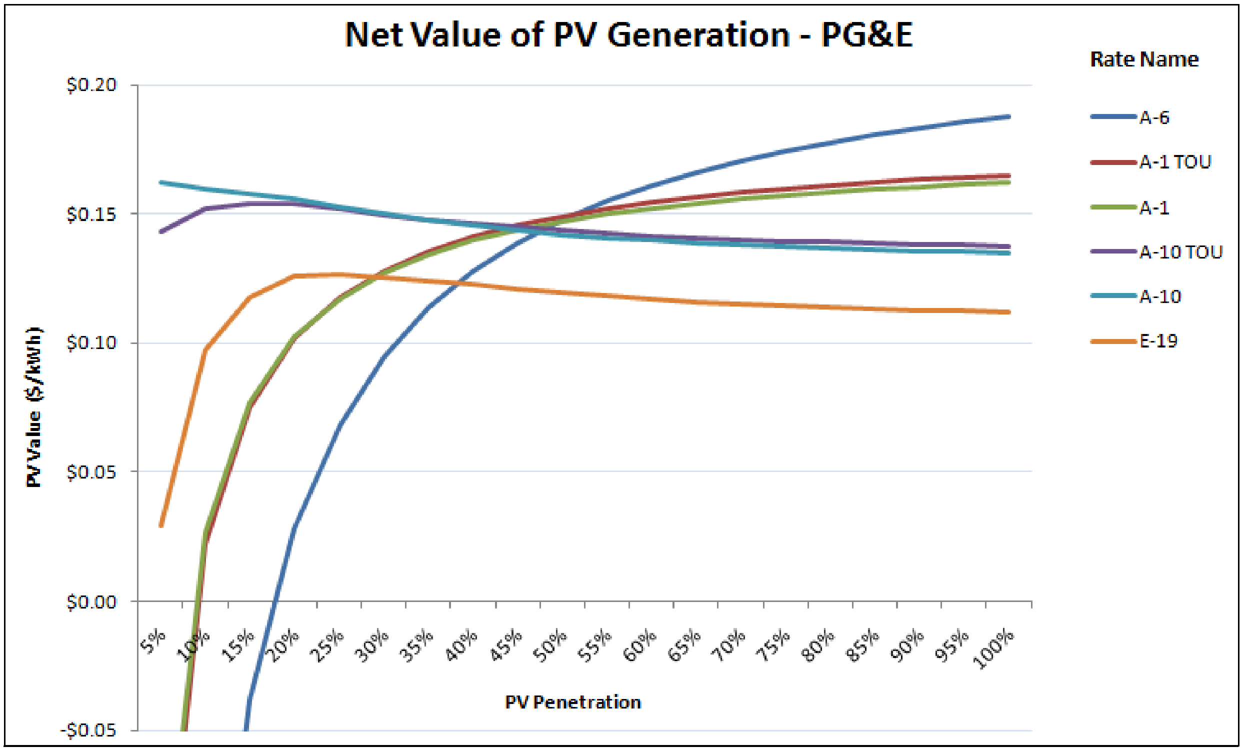


**Figure 6. Net value of PV generation under various rate structures and penetration levels for a school in the PG&E service territory**

It is important to note that we do not consider impacts of system cost in this analysis. Businesses may purchase the system with cash, finance the system through a loan, or use third-party financing such as a power purchase agreement (PPA) or solar lease. In order to assess the economic feasibility of a solar project, it is necessary to evaluate both the costs and benefits that the PV system provides over time. Several metrics that are used to evaluate economic performance of PV systems include, but are not limited to: break-even cost, internal rate of return, simple payback period, and net annual bill savings. Several reports have described or used these metrics to evaluate rooftop PV systems (Denholm et al. 2009; Ong and Denholm 2011; Short et al. 1995).

# 3 Results

The impact of rates, building types, solar penetration, and location was evaluated across 1,232 unique datasets. The aggregated results show trends across major categories. Furthermore, the aggregated results only consider the best rate choices: reported averages do not include results from sub-optimal rate options. Detailed results for each building type, location, and rate (including sub-optimal rate choices) are provided in Appendix A and Appendix C.

## 3.1 Net Value of Solar

We examine the distribution of the net solar values calculated for PV penetration levels that yield the highest net solar value. Figure 7 compares the net solar value distribution with the distribution of electricity prices evaluated. On average, the solar value at each location is $0.03 lower than the least-cost retail electricity rate without solar. The lower solar value is a result of the prevalence of demand charges in the rates used for this study. Seventy percent of all rates evaluated utilized demand charges, which typically reduce solar value (Ong et al. 2010).

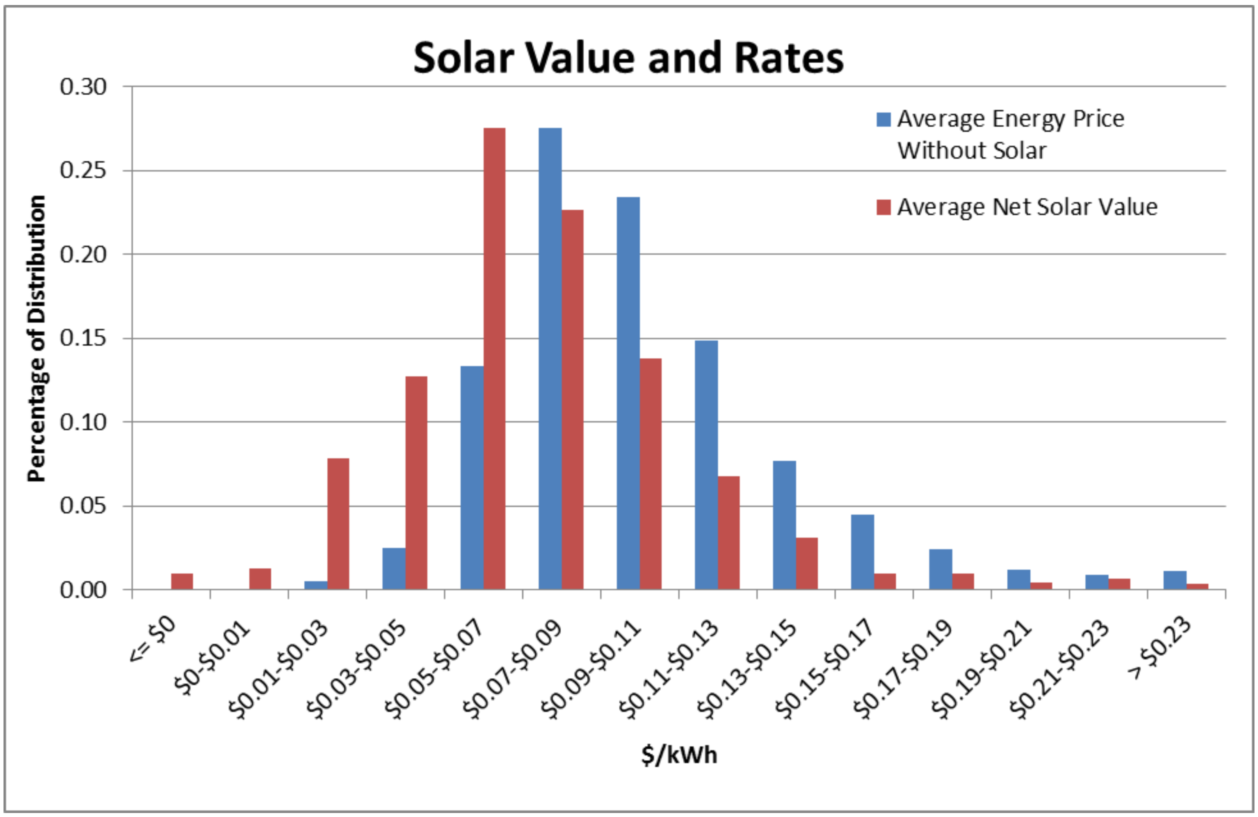


**Figure 7. Distribution of electricity prices and calculated solar values**

Figure 8 shows the average solar value for all building types evaluated. Although solar value varies up to 30% by building type, the location is a bigger driver of solar value differences. Figure 9 shows the average solar value by location, with error bars designating differences due to building type. The primary driver of solar value by location is regional electricity price, and not solar resource. For example, New Orleans's solar resource is 13% greater than Green Bay, Wisconsin. Yet, the net solar value in Green Bay is 440% greater than in New Orleans.[8] Solar resource in the United States varies by less than a factor of 2, while our results indicate that solar value vary by more than a factor of 10.

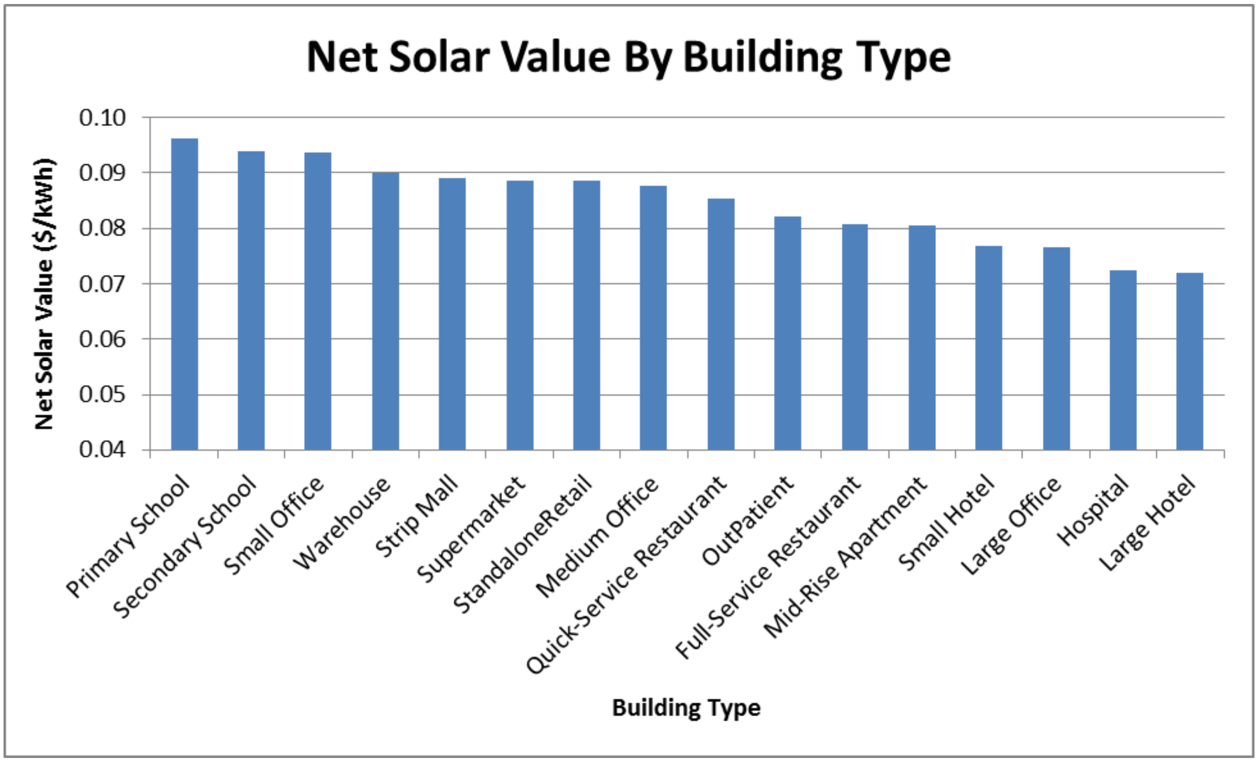


**Figure 8. Average solar value for each building type**

[8] New Orleans is served by Entergy Louisiana, which utilizes commercial rates with high levels of demand charges. This causes a reduction in PV value. The high PV value in Green Bay is driven by Wisconsin Electric Power's rate schedule Cg 6, which includes very high TOU energy rates.

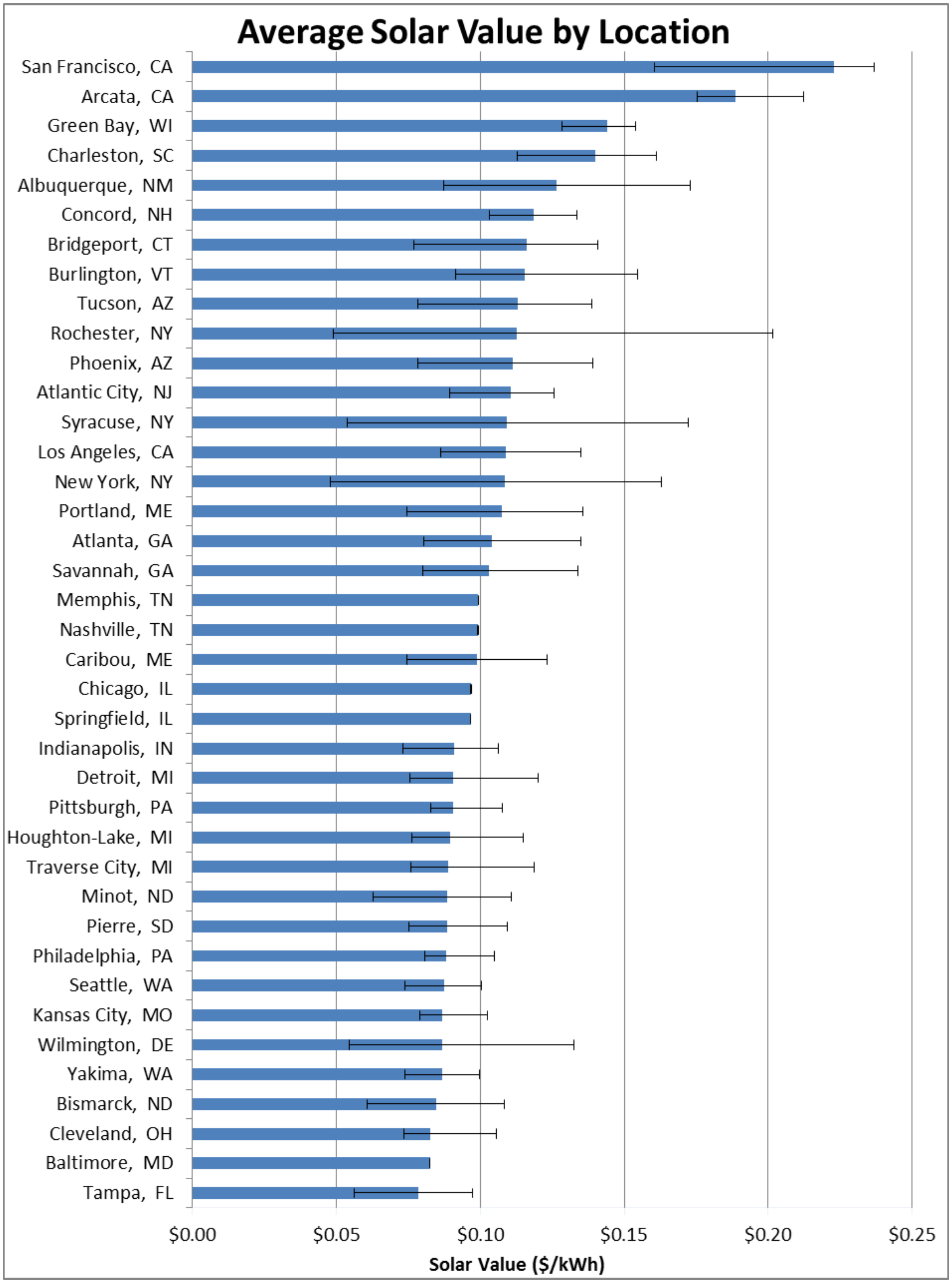


**Figure 9a. Average solar value for the top 39 locations**

Note: Error bars designate the range of values resulting from building type differences.

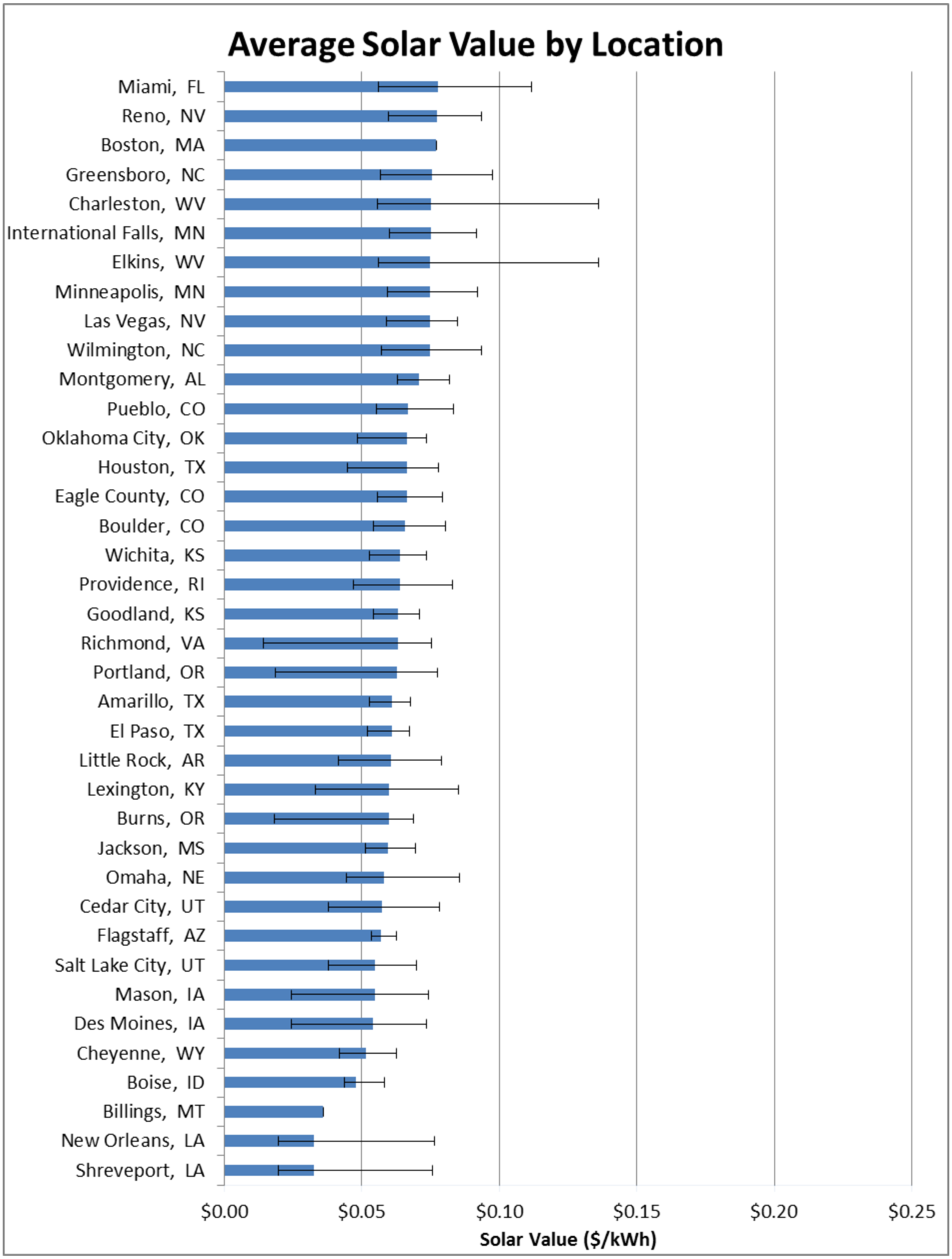


**Figure 9b. Average solar value for the next 38 locations**

Note: Error bars designate the range of values resulting from building type differences.

Figure 10 shows the average solar value by six of the most common commercial rate structure combinations evaluated. On average, flat energy rates produce the highest solar value. Flat rate structures with demand charges reduce the average value by 17%. Tiered rates with demand charges result in a 21% reduction in value compared with energy-only tiered rates. TOU rates with demand charges, however, demonstrate a 6% increase in solar value compared with energy-only TOU rates.

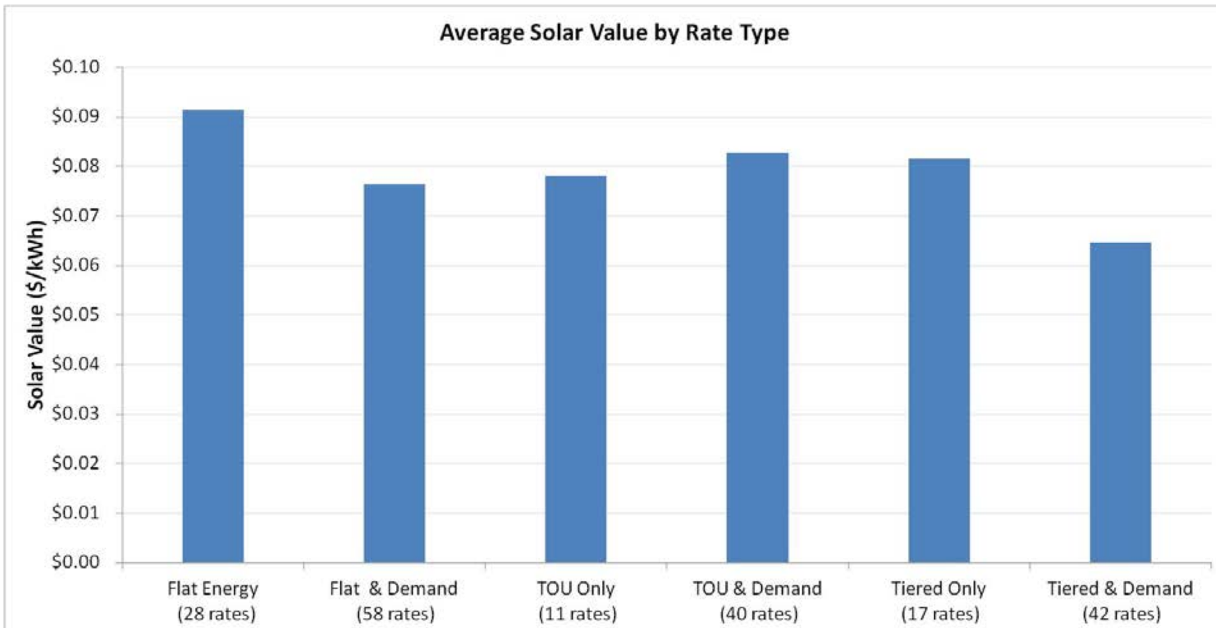


**Figure 10. Solar value by rate type, averaged across all locations and building types evaluated**

## 3.2 Impact of PV Building Penetration

Building load profile, utility rate structure, and solar generation interact such that the value (per kilowatt-hour) that a PV system provides is dependent on PV penetration. PV penetration is defined as the percentage of a facility's annual electrical energy consumption that is met by a PV system. Table 3 shows the PV system size required to reach 100% penetration for each building type, averaged over all locations. Regions with higher solar insolation will require slightly smaller system capacities, and those with less sunlight will require larger capacities. For reference, the maximum rooftop penetration was estimated for each building type[9] and provides an approximate solar penetration value, should the PV installation be limited to the building's rooftop area. This analysis evaluates penetration levels from 0% to 100% because a building's PV system location is not limited to the rooftop area but may be installed on awnings, facades, parking garages, and other structures.[10]

[9] An estimate for maximum rooftop solar capacity is calculated by assuming a 14% module efficiency (140 Watts per square meter) and utilization of 50% of the total rooftop area (to account for potential obstructions due to HVAC equipment and other infrastructure.) Each building's rooftop area is assumed to be equivalent to the floor space area. For multi-story structures, the total rooftop area is assumed to be equivalent to the area of a single floor.

[10] Note that placing PV systems on facades and other structures with sub-optimal orientation are likely to have lower PV performance (James et al. 2011).

**Table 3. Average PV Penetration Values by Building Type**

| Building Type | Roof Area ($m^2$) | Peak Power (kW) | Maximum Rooftop Solar[a] (kW) | 100% Penetration Solar Size (kW) | Maximum Solar Energy Penetration |
|---|---|---|---|---|---|
| Full-Service Restaurant | 511 | 68 | 36 | 237 | 15.2% |
| Hospital | 3,737 | 1,510 | 262 | 6,861 | 4.6% |
| Large Hotel | 1,621 | 553 | 113 | 2,095 | 6.3% |
| Large Office | 3,563 | 1,580 | 249 | 4,600 | 5.9% |
| Medium Office | 1,661 | 318 | 116 | 549 | 21.1% |
| Mid-Rise Apartment | 784 | 67 | 55 | 178 | 30.8% |
| Outpatient | 1,268 | 321 | 89 | 1,023 | 8.7% |
| Primary School | 6,871 | 328 | 481 | 654 | 73.6% |
| Quick-Service Restaurant | 232 | 39 | 16 | 143 | 11.2% |
| Secondary School | 9,796 | 1,178 | 686 | 2,341 | 29.3% |
| Small Hotel | 1,003 | 133 | 70 | 443 | 15.8% |
| Small Office | 511 | 19 | 36 | 49 | 73.6% |
| Standalone Retail | 2,319 | 104 | 162 | 241 | 67.2% |
| Strip Mall | 2,090 | 93 | 146 | 219 | 66.8% |
| Supermarket | 4,181 | 367 | 293 | 1,245 | 23.5% |
| Warehouse | 4,835 | 96 | 338 | 199 | 170.1% |

[a] An estimate for maximum rooftop solar capacity is calculated assuming a 14% module efficiency and utilization of 50% of the total rooftop area (to avoid obstructions such as HVAC equipment.)

Our results indicate that in many cases, a single rate structure option has the highest solar value for all penetration levels. An example of this is shown in Figure 11 (for a strip mall in Houston, Texas), where rate GS provides the highest net solar value. The declining solar value with increasing penetration is due to the inability of solar generation to offset demand charges that occur during non-sunlight hours (Wiser et al. 2007). Figure 12 shows an example of one rate structure providing the highest solar value for low penetrations (rate A-10 TOU), while another rate structure becomes more valuable at higher penetrations (rate A-6). The scenario in Figure 11 shows that the highest solar value occurs at the smallest penetration, while Figure 12 shows the highest solar value at the maximum penetration.

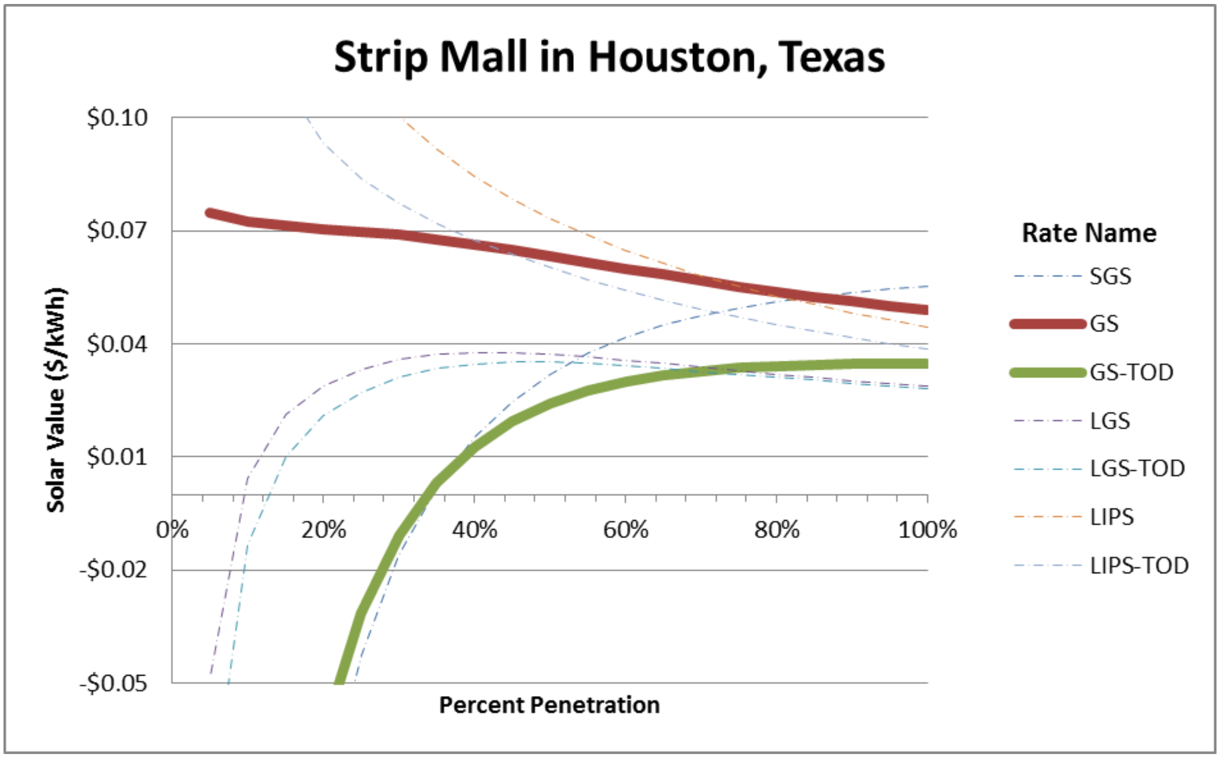


**Figure 11. Net solar value with respect to penetration for all Entergy Texas rates evaluated**

Note: Dotted lines represent rates that are not applicable to this building and are included for reference purposes only.

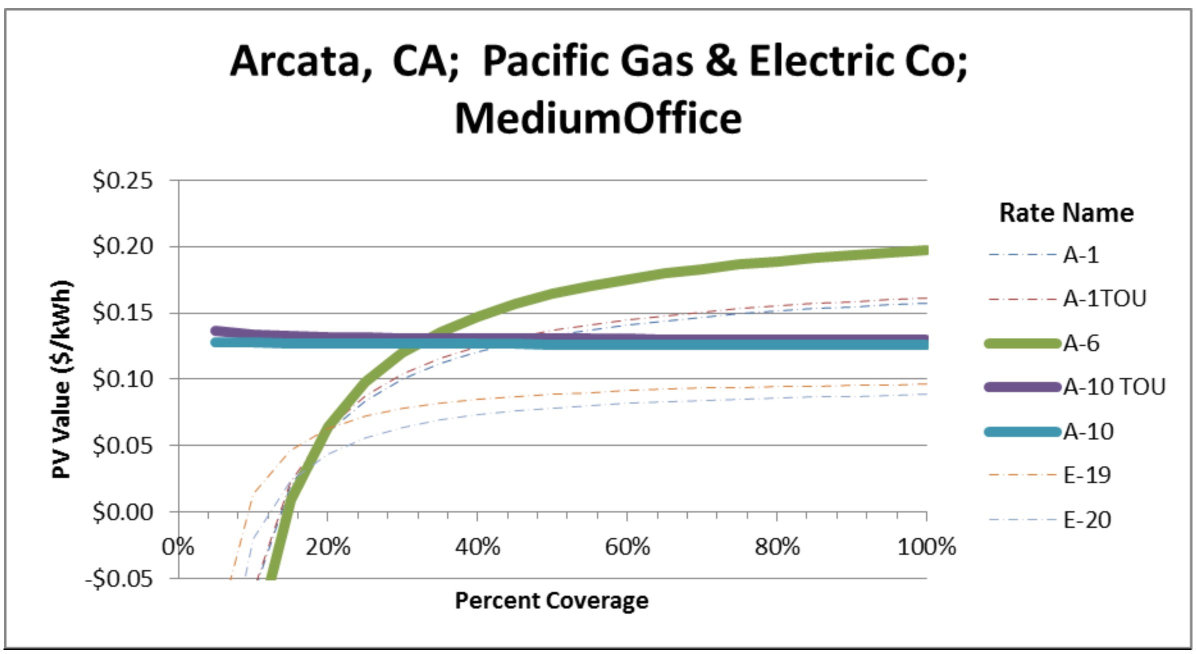


**Figure 12. Net solar value with respect to penetration for all PG&E rates evaluated**

Note: Dotted lines represent rates that are not applicable to this building and are included for reference purposes only.

Figure 13 shows the distribution of optimal penetration levels for all locations and building types evaluated. The highest solar values occur at very small penetrations in 63% of cases, while they occur at maximum penetration 26% of the time. This pattern occurs because under most demand-based rates, smaller PV penetrations yield greater value (Wiser et al. 2007), while TOU rates favor large PV penetrations due to the coincidence of high rates and solar resource (Ong et al. 2010).

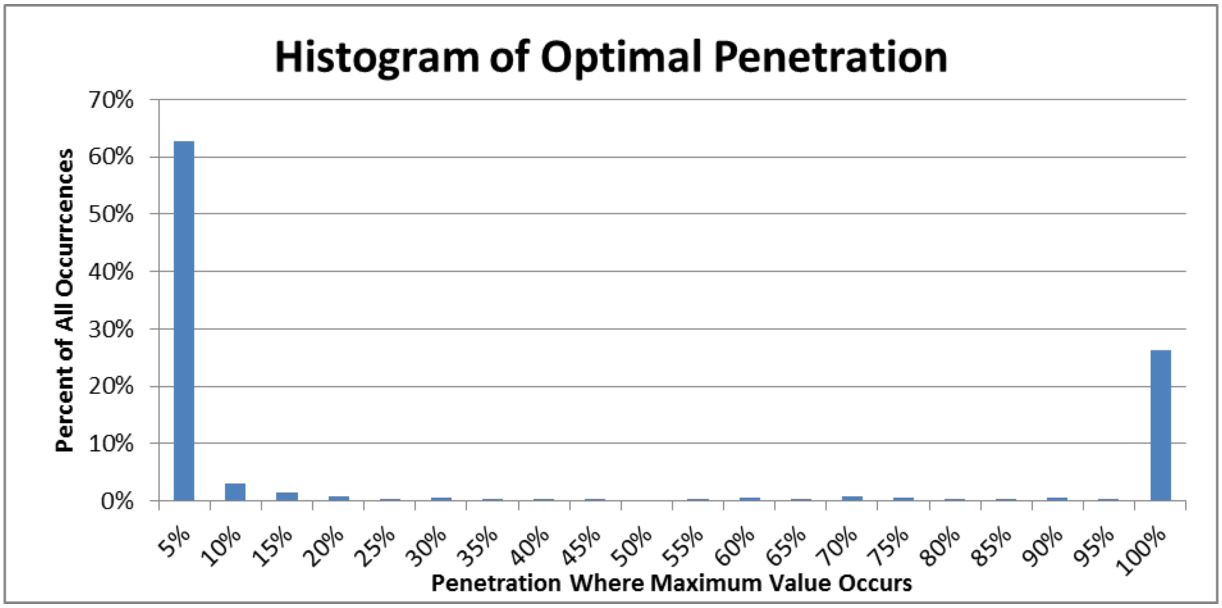


**Figure 13. Distribution of optimal penetration levels for all locations and building types evaluated**

It is important to note that the data in Figure 13 represent shallow optimums. Figure 14 compares all solar values relative to the highest solar value, averaged for all locations and buildings. Results indicate that even "least-optimal" penetration levels are still within 85% of the highest solar value at the optimum penetration.

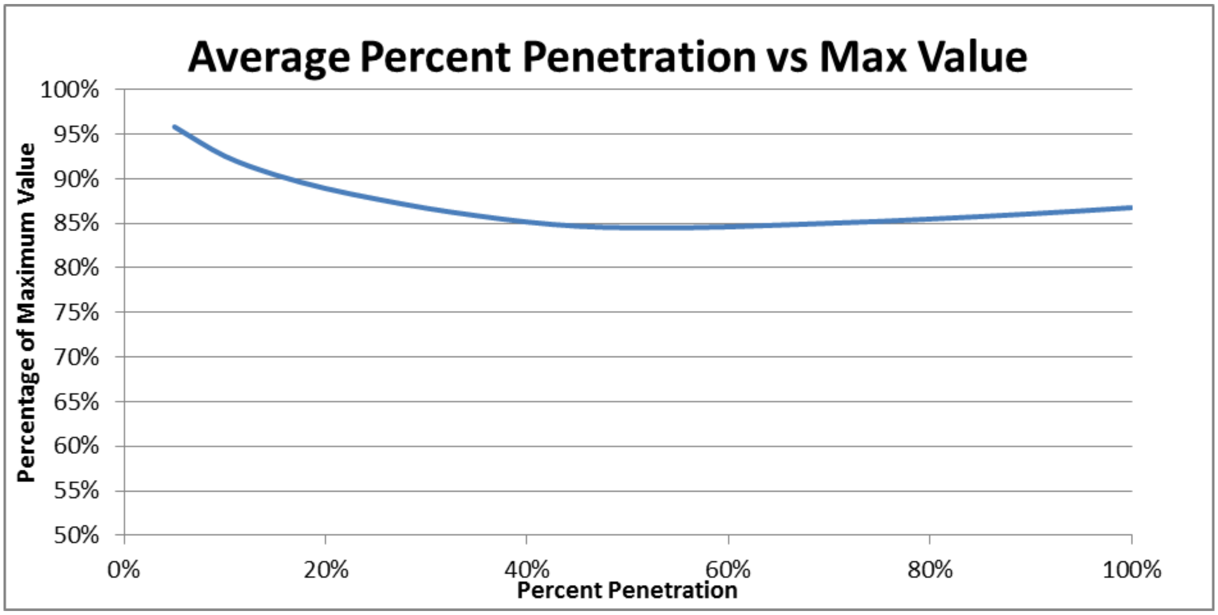


**Figure 14. Comparison of solar values relative to the highest solar value, averaged for all locations and building types**

# 4 Conclusion

An evaluation of 16 different building types across 77 locations reveals that PV system value is highly dependent on the host building's rate structure. Although PV system economic performance may vary up to 30% by building type, regional electricity price differences are the primary driver of solar economics across the United States, causing solar value to vary by a factor of 10. System economics—under current net-metering rules—favor TOU rates and rates with little or no demand charges. This analysis found that there is often no single best rate. Rather, the most economical rate depends on PV penetration level with reference to the building electricity load. Optimal penetration levels are most often either very small (5%) or very large (100%), although penetration level effects are shown to exhibit shallow optimums.

These results identify general relationships between rate structures and PV installations on commercial buildings. This rate analysis applies to simulated load profiles (see Section 2.2) and is not intended to represent all buildings in the United States. Recommendations for future studies include identifying the impacts of potential changes in net-metering rules and evaluating additional sensitivities that have an impact on system economics, such as financing options and PV array orientation.

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# Appendix A

**Table A-1. List of Utilities and Rates Evaluated With Information About Their Rate Type, Average Price Without Solar, Average Maximum Solar Value, and Applicable Range**

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| Alabama Power Co | LPSE | | ✓ | | ✓ | $0.126 | $0.043 | 0-50 |
| | LPME | | ✓ | | ✓ | $0.082 | $0.057 | 50 and Up |
| | LPL | | ✓ | | ✓ | $0.077 | $0.070 | 0-20,000 |
| | LPLE | | ✓ | | ✓ | $0.074 | $0.051 | 1,200-20,000 |
| | BTA | | ✓ | ✓ | | $0.095 | $0.034 | 0 and Up |
| | LPM | | ✓ | | ✓ | $0.100 | $0.054 | 0 and Up |
| | SCH | | ✓ | | ✓ | $0.077 | $0.069 | 0 and Up |
| Entergy Arkansas Inc | SGS | | ✓ | | ✓ | $0.069 | $0.064 | 6-100 |
| | LGS | ✓ | ✓ | | | $0.070 | $0.063 | 100-1,000 |
| | LGS-TOU | | ✓ | ✓ | | $0.079 | $0.019 | 100-1,000 |
| | LPS | ✓ | ✓ | | | $0.062 | $0.057 | 1,000 and Up |
| | LPS-TOU | | ✓ | ✓ | | $0.059 | $0.033 | 1,000 and Up |
| Salt River Project | E-32 | | ✓ | ✓ | | $0.073 | $0.016 | 0 and Up |
| | E-34 | | | ✓ | | $0.082 | $0.013 | 0 and Up |
| | E-36 | | ✓ | | ✓ | $0.060 | $0.058 | 0 and Up |
| | E-61 | | ✓ | ✓ | | $0.053 | $0.021 | 417 and Up |
| | E-63 | | | ✓ | | $0.055 | $0.041 | 417 and Up |
| | E-65 | | | ✓ | | $0.050 | $0.033 | 1,000 and Up |
| Arizona Public Service Co | E-32 TOU (ES) | | | ✓ | | | | 0-20 |
| | E-32 TOU (S) | | ✓ | ✓ | | $0.116 | $0.101 | 21-100 |
| | E-32 TOU M | | ✓ | ✓ | | $0.124 | $0.106 | 101-400 |
| | E-32 (L) | ✓ | ✓ | | | $0.086 | $0.079 | 400 and Up |
| | E-32 TOU (L) | | ✓ | ✓ | | $0.102 | $0.040 | 400 and Up |
| | SOLAR-3 | ✓ | | | | $0.158 | $0.115 | 0 and Up |
| Pacific Gas & Electric Co | A-1 | ✓ | | | | $0.176 | $0.181 | 0-200 |
| | A-1TOU | | | ✓ | | $0.167 | $0.160 | 0-200 |
| | A-6 | | | ✓ | | $0.185 | $0.145 | 200 and Up |
| | A-10 TOU | | ✓ | ✓ | | $0.113 | $0.129 | 200-499 |
| | A-10 | ✓ | ✓ | | | $0.104 | $0.109 | 200-500 |
| | E-19 | | ✓ | ✓ | | $0.109 | $0.119 | 500-1,000 |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| | E-20 | | ✓ | ✓ | | $0.151 | $0.172 | 1,000 and Up |
| City of Los Angeles California (Utility Company) | A-SGS | ✓ | ✓ | | | $0.154 | $0.178 | 0-30 |
| | B-SGS | | ✓ | ✓ | | $0.171 | $0.178 | 0-30 |
| | A-2 | ✓ | ✓ | | | $0.127 | $0.098 | 30 and Up |
| | A-2 TOU | | ✓ | ✓ | | $0.131 | $0.100 | 30 and Up |
| | A-SUB | | ✓ | ✓ | | $0.126 | $0.081 | 30 and Up |
| | B-SUB | ✓ | ✓ | | | $0.116 | $0.107 | 30 and Up |
| Southern California Edison Co | GS-1 | ✓ | | | | $0.159 | $0.142 | 0-20 |
| | GS-2-TOU-R | | ✓ | ✓ | | $0.200 | $0.206 | 20-200 |
| | GS-1-TOU | ✓ | | | | $0.177 | $0.134 | 20 and Up |
| | GS-3-TOU-R | | ✓ | ✓ | | $0.140 | $0.107 | 200-500 |
| | TOU-8-R | | ✓ | ✓ | | $0.123 | $0.073 | 500 and Up |
| Public Service Co of Colorado | C | ✓ | | | | $0.095 | $0.099 | 0-25 |
| | SG | ✓ | ✓ | | | $0.083 | $0.032 | 0 and Up |
| | STOU | ✓ | ✓ | | | $0.078 | $0.086 | 0 and Up |
| Connecticut Light & Power Co | 27 | ✓ | ✓ | | | $0.173 | $0.196 | 0-350 |
| | 37 | ✓ | ✓ | | | $0.152 | $0.166 | 200-350 |
| | 56 | ✓ | ✓ | | | $0.161 | $0.135 | 350-1,000 |
| | 58 | ✓ | ✓ | | | $0.102 | $0.079 | 1,000 and Up |
| Delmarva Power & Light Co | SGS-S | ✓ | | | | | | 0-15 |
| | MGS-S | ✓ | ✓ | | | $0.079 | $0.070 | 15-300 |
| | LGS-S | | ✓ | ✓ | | $0.120 | $0.098 | 300 and Up |
| Florida Power & Light Co. | GS-1 | ✓ | | | | | | 0-20 |
| | GST-1 | | | ✓ | | | | 0-20 |
| | GSD-1 | ✓ | ✓ | | | $0.087 | $0.080 | 20-500 |
| | GSDT-1 | | ✓ | ✓ | | $0.080 | $0.057 | 20-500 |
| | GSLD-1 | ✓ | ✓ | | | $0.075 | $0.065 | 500-2,000 |
| | GSLDT-1 | | ✓ | ✓ | | $0.084 | $0.100 | 500-2,000 |
| Georgia Power Co | PLS-7 | | | | ✓ | $0.138 | $0.132 | 0-30 |
| | TOU-EO-6 | | | ✓ | ✓ | $0.168 | $0.112 | 0-30 |
| | PLM-7 | | | | ✓ | $0.119 | $0.101 | 30-500 |
| | TOU-GSD-6 | | ✓ | ✓ | | $0.104 | $0.094 | 30-500 |
| | PLL-7 | | | | ✓ | $0.112 | $0.083 | 500 and Up |
| | TOU-SSD-6 | | ✓ | ✓ | | $0.093 | $0.091 | 500 and Up |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| MidAmerican Energy Co (Iowa) | GBS | | | | ✓ | $0.079 | $0.069 | 0-200 |
| | GUS | | | ✓ | | $0.069 | $0.074 | 0-200 |
| | LLS | | ✓ | | ✓ | $0.043 | $0.057 | 200 and Up |
| | LNS | | ✓ | ✓ | | $0.075 | $0.034 | 200 and Up |
| Idaho Power Co | sc7 SGS | | | | ✓ | | | 0-3 |
| | sc9 LGS | | ✓ | | ✓ | $0.053 | $0.050 | 3-1,000 |
| | sc19 LPS | | ✓ | ✓ | | $0.050 | $0.045 | 1,000 and Up |
| Commonwealth Edison Co | GSSL | ✓ | ✓ | | | $0.108 | $0.069 | 0-100 |
| | GSML | ✓ | ✓ | | | $0.107 | $0.075 | 100-400 |
| | GSLL | ✓ | ✓ | | | $0.091 | $0.071 | 400-1,000 |
| | GSVL | ✓ | ✓ | | | $0.090 | $0.070 | 1,000-10,000 |
| | WHDC | ✓ | | | | $0.094 | $0.096 | 0 and Up |
| Duke Energy Indiana Inc | LLF | | ✓ | ✓ | | $0.098 | $0.094 | 0 and Up |
| | LLF-TOU | | | | ✓ | $0.109 | $0.080 | 0 and Up |
| Westar Energy Inc | SGS south | | ✓ | | ✓ | $0.070 | $0.075 | 0 and Up |
| | MGS south | ✓ | ✓ | | | $0.081 | $0.055 | 200 and Up |
| | HLF | ✓ | ✓ | | | $0.081 | $0.044 | 1,000 and Up |
| Kentucky Utilities Co | GS | ✓ | | | | $0.078 | $0.093 | 0-50 |
| | PS | ✓ | ✓ | | | $0.085 | $0.072 | 50-250 |
| | TODS | ✓ | ✓ | | | $0.059 | $0.058 | 250-5,000 |
| Entergy Louisiana Inc | LGS-21 | | ✓ | | ✓ | $0.045 | $0.051 | 0-3,000 |
| | GS-1W | | ✓ | | ✓ | $0.068 | $0.039 | 0 and Up |
| | MMRAS | | ✓ | | ✓ | $0.063 | $0.020 | 0 and Up |
| Massachusetts Electric Co | G-1 | | | | ✓ | $0.075 | $0.079 | 0 and Up |
| | G-2 | ✓ | ✓ | | | $0.095 | $0.065 | 0-200 |
| | G-3 | ✓ | ✓ | | | $0.094 | $0.065 | 180 and Up |
| Baltimore Gas & Electric Co | SG | ✓ | | | | $0.101 | $0.060 | 0 and Up |
| | SGS | ✓ | | ✓ | | $0.068 | $0.061 | 2.8 and Up |
| | SGL | | ✓ | ✓ | | $0.104 | $0.065 | 60 and Up |
| Bangor Hydro-Electric Co | GS | ✓ | | | | $0.076 | $0.074 | 0-25 |
| | MP | ✓ | ✓ | | | $0.118 | $0.097 | 25 and Up |
| Detroit Edison Co | D3.4 TOU | ✓ | | | | $0.107 | $0.080 | 0 and Up |
| | D4 LGS | | ✓ | | ✓ | $0.090 | $0.067 | 0 and Up |
| Northern States | A-12 | ✓ | | | | $0.071 | $0.055 | 0-25 |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| Power Co (Minnesota) Excel Energy | A-16 | ✓ | | | | $0.087 | $0.049 | 0-25 |
| | A-10 | ✓ | | | | $0.090 | $0.069 | 0-25 |
| | A-14 | ✓ | ✓ | | | $0.083 | $0.072 | 0-1,000 |
| | A-15 | ✓ | ✓ | | | $0.087 | $0.055 | 0 and Up |
| | A-23 | ✓ | ✓ | | | $0.088 | $0.046 | 0-1,000 |
| | A-24 | ✓ | ✓ | | | $0.086 | $0.075 | 0 and Up |
| Union Electric Co | 2(M) | ✓ | | | | $0.091 | $0.070 | 0-100 |
| | 2(M)-TOD | ✓ | | | | $0.078 | $0.075 | 0-100 |
| | 3(M) | | ✓ | | ✓ | $0.093 | $0.087 | 100 and Up |
| | 3(M)-TOD | | ✓ | ✓ | ✓ | $0.095 | $0.083 | 100 and Up |
| Entergy Mississippi Inc | GS-295 | | | | ✓ | $0.066 | $0.086 | 0 and Up |
| | B-31 | | ✓ | | ✓ | $0.068 | $0.090 | 200 and Up |
| | HLF-4 | | ✓ | | ✓ | $0.065 | $0.076 | 200 and Up |
| | C-26 | | ✓ | | ✓ | $0.061 | $0.065 | 1,000 and Up |
| | ALGS-7 | ✓ | ✓ | | | | | 5,000 and Up |
| North Western Corporation | GSEDS-1 | ✓ | | | | $0.036 | $0.035 | 0 and Up |
| | GS-1 | ✓ | ✓ | | | $0.087 | $0.050 | 0 and Up |
| Duke Energy Carolinas LLC | SGS | | ✓ | | ✓ | $0.093 | $0.042 | 0-75 |
| | LGS | | ✓ | | ✓ | $0.081 | $0.067 | 75 and Up |
| | OPT-G (NC) | ✓ | ✓ | | | $0.076 | $0.074 | 0 and Up |
| Montana-Dakota Utilities Co (North Dakota) | SGES-20 | | | | ✓ | $0.078 | $0.069 | 0-20 |
| | SGTOD-25 | | | ✓ | | $0.063 | $0.065 | 0-20 |
| | GES-30 | ✓ | ✓ | | | $0.095 | $0.055 | 0 and Up |
| | GESTOD-31 | | ✓ | ✓ | | $0.090 | $0.061 | 0 and Up |
| Omaha Public Power District | GS-230 | | | | ✓ | $0.036 | $0.024 | 0-50 |
| | GS-231 | | ✓ | | ✓ | $0.052 | $0.039 | 50-1,000 |
| | GS-232 | | ✓ | | ✓ | $0.030 | $0.019 | 1,000 and Up |
| Public Service Co of NH | G-OTOD | ✓ | ✓ | | | $0.130 | $0.048 | 0 and Up |
| | G | | ✓ | | ✓ | $0.128 | $0.090 | 0 and Up |
| | GV | | ✓ | | ✓ | $0.133 | $0.088 | 0 and Up |
| | LG | ✓ | ✓ | | | $0.131 | $0.080 | 0 and Up |
| Public Service Elec & Gas Co | BGS-FP | | ✓ | ✓ | | $0.105 | $0.082 | 0-750 |
| | LPL | | ✓ | ✓ | | $0.106 | $0.084 | 150 and Up |
| Public Service Co | 2A | ✓ | | | | $0.094 | $0.070 | 0-50 |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| of NM | 2B | ✓ | | | | $0.166 | $0.136 | 0-50 |
| | 3B | | ✓ | ✓ | | $0.132 | $0.096 | 50 and Up |
| | 3C | | ✓ | ✓ | | $0.132 | $0.116 | 50 and Up |
| | 4B | | ✓ | ✓ | | $0.104 | $0.114 | 500 and Up |
| Nevada Power Co | GS | ✓ | | | | | | 0-5 |
| | OGS-TOU | ✓ | | | | | | 0-5 |
| | LGS-1 | ✓ | ✓ | | | $0.089 | $0.083 | 5-300 |
| | LGS-2 | | ✓ | ✓ | | $0.073 | $0.072 | 300-1,000 |
| | LGS-3 | | ✓ | ✓ | | $0.081 | $0.085 | 1,000 and Up |
| | LGS-X | | ✓ | ✓ | | | | 25,000 and Up |
| Consolidated Edison Co-NY Inc | SC2-I | | | | ✓ | | | 0-10 |
| | SC2-II | | | ✓ | | | | 0-10 |
| | SC9-I | ✓ | ✓ | | | $0.238 | $0.107 | 10-1,500 |
| | SC9-III | ✓ | ✓ | | | $0.163 | $0.092 | 10-1,500 |
| | SC9-II | ✓ | ✓ | | | $0.089 | $0.054 | 1,500 and Up |
| Ohio Power Co | GS-1 | ✓ | | | | | | 0-10 |
| | GS-2 | ✓ | ✓ | | | $0.096 | $0.062 | 10-8,000 |
| | GS-TOD | ✓ | | | | $0.085 | $0.082 | 0-500 |
| Oklahoma Gas & Electric Co | GS-1 | | | | ✓ | $0.077 | $0.066 | 10-400 |
| | GS-TOU | | | | ✓ | $0.067 | $0.069 | 10-400 |
| | PL | ✓ | ✓ | | | $0.064 | $0.074 | 400 and Up |
| | PL-TOU | | ✓ | ✓ | | $0.058 | $0.054 | 400 and Up |
| PacifiCorp (Oregon) | 23-200 | | | | ✓ | $0.074 | $0.042 | 0-30 |
| | 23-210 | | | ✓ | | $0.052 | $0.057 | 0-30 |
| | 28-200 | | ✓ | | ✓ | $0.078 | $0.068 | 31-200 |
| | 28-210 | ✓ | ✓ | | ✓ | $0.093 | $0.066 | 31-200 |
| | 30-200 | ✓ | ✓ | | ✓ | $0.092 | $0.068 | 201-999 |
| | 47-3,999 Self Generating | ✓ | ✓ | | | $0.079 | $0.056 | 0-4,000 |
| | 47-4,000 Self Generating | ✓ | ✓ | | | | | 4,000 and Up |
| PECO Energy Co | GS-2 | ✓ | ✓ | | ✓ | $0.088 | $0.076 | 0-100 |
| | GS-3 | | ✓ | | ✓ | $0.086 | $0.076 | 101-500 |
| | GS-4 | | ✓ | | ✓ | $0.091 | $0.085 | 500 and Up |
| The Narragansett | C-06 | ✓ | ✓ | | | $0.125 | $0.028 | 0-200 |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| Electric Co | G-02 | ✓ | ✓ | | | $0.056 | $0.041 | 10-200 |
| | G-32 | ✓ | ✓ | | | $0.063 | $0.020 | 200 and Up |
| South Carolina Electric & Gas Co | 9 | | | | ✓ | $0.155 | $0.123 | 0 and Up |
| | 20 | | ✓ | | ✓ | $0.124 | $0.095 | 75 and Up |
| | 21 | | ✓ | ✓ | | $0.130 | $0.077 | 50-1,000 |
| Black Hills Power Inc | GS | | ✓ | | ✓ | $0.112 | $0.077 | 0 and Up |
| | GS (TE) | | ✓ | | ✓ | $0.102 | $0.081 | 0 and Up |
| | GL | | | | ✓ | $0.080 | $0.077 | 125 and Up |
| City of Memphis Tennessee (Utility Company) | GSA | | | ✓ | | $0.100 | $0.099 | 0-5,000 |
| | TDGSA | | ✓ | | ✓ | $0.158 | $0.045 | 1,000-5,000 |
| | TGSA | ✓ | ✓ | | | $0.098 | $0.061 | 1,000-5,000 |
| CPS Energy | PL | | | | ✓ | $0.063 | $0.068 | 0 and Up |
| | LLP | | ✓ | | ✓ | $0.079 | $0.038 | 0 and Up |
| | ELP | | ✓ | | ✓ | $0.060 | $0.042 | 1,000 and Up |
| Entergy Texas Inc. | SGS | ✓ | | | | | | 0-20 |
| | GS | ✓ | ✓ | | | $0.078 | $0.080 | 5-2,500 |
| | GS-TOD | | ✓ | ✓ | | $0.108 | $0.034 | 5-2,500 |
| | LGS | ✓ | ✓ | | | $0.065 | $0.057 | 300-2,500 |
| | LGS-TOD | | ✓ | ✓ | | $0.064 | $0.053 | 300-2,500 |
| | LIPS | ✓ | ✓ | | | | | 2,500 and Up |
| | LIPS-TOD | ✓ | ✓ | | | | | 2,500 and Up |
| Moon Lake Electric Assn Inc (Utah) | GS-3 | ✓ | | | | $0.085 | $0.101 | 0-49 |
| | LP | ✓ | ✓ | | | $0.072 | $0.069 | 50 and Up |
| Virginia Electric & Power Co | GS-1 | | | | ✓ | $0.084 | $0.105 | 0-30 |
| | GS-2 | ✓ | | | | $0.104 | $0.063 | 30-500 |
| | DP-2 | | ✓ | ✓ | | $0.066 | $0.087 | 30-500 |
| | GS-2 | ✓ | ✓ | | | $0.072 | $0.079 | 500 and Up |
| Central Vermont Pub Serv Corp | Rate 10 | ✓ | | | | $0.150 | $0.084 | 0 and Up |
| | Rate 2 | | ✓ | | ✓ | $0.133 | $0.123 | 0 and Up |
| Puget Sound Energy Inc | 24 | ✓ | | | | $0.099 | $0.102 | 0-50 |
| | 25 | | ✓ | | ✓ | $0.102 | $0.086 | 50-350 |
| | 26 | ✓ | ✓ | | | $0.094 | $0.083 | 350 and Up |
| Wisconsin Electric Power Co | Cg 1 | ✓ | | | | | | 0-14 |
| | Cg 2-A | ✓ | ✓ | | | $0.116 | $0.105 | 14 and Up |

| Utility | Rate | Flat Seasonal | Demand | TOU | Tiered | Average Price | Average Solar Value | Applicability (kW) |
|---|---|---|---|---|---|---|---|---|
| | Cg 2-B | ✓ | ✓ | | | $0.101 | $0.100 | 14-42 |
| | Cg 3 | ✓ | ✓ | | | $0.131 | $0.069 | 42 and Up |
| | Cg 6-A | ✓ | | | | $0.135 | $0.144 | 0 and Up |
| | Cg 6-B | ✓ | | | | $0.138 | $0.133 | 0 and Up |
| Harrison Rural Elec Assn Inc | Sch B | ✓ | | | | $0.125 | $0.094 | 0-50 |
| | C&1 | | ✓ | | ✓ | $0.075 | $0.068 | 50 and Up |
| Powder River Energy Corporation | GS | ✓ | | | | $0.070 | $0.063 | 0-50 |
| | LP | | ✓ | | ✓ | $0.058 | $0.050 | 50 and Up |

# Appendix B

**Table B-1. Maximum Solar Value Found for Each Building Type in Each Location**

| Location | Full-Service Restaurant | Hospital | Large Hotel | Large Office | Medium Office | Mid-Rise Apartment | Out Patient | Primary School | Quick-Service Restaurant | Secondary School | Small Hotel | Small Office | Standalone Retail | Strip Mall | Supermarket | Warehouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Montgomery, AL | 0.07 | 0.07 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.07 | 0.08 | 0.06 | 0.08 | 0.07 | 0.07 | 0.08 | 0.08 |
| Little Rock, AR | 0.06 | 0.05 | 0.04 | 0.05 | 0.06 | 0.06 | 0.06 | 0.08 | 0.06 | 0.07 | 0.04 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 |
| Flagstaff, AZ | 0.05 | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Phoenix, AZ | 0.11 | 0.08 | 0.08 | 0.09 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.11 | 0.14 | 0.13 | 0.13 | 0.09 | 0.14 |
| Tucson, AZ | 0.11 | 0.08 | 0.08 | 0.10 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 | 0.11 | 0.14 |
| Arcata, CA | 0.19 | 0.18 | 0.19 | 0.19 | 0.20 | 0.19 | 0.18 | 0.19 | 0.19 | 0.21 | 0.19 | 0.19 | 0.18 | 0.18 | 0.19 | 0.19 |
| Los Angeles, CA | 0.11 | 0.09 | 0.09 | 0.09 | 0.12 | 0.09 | 0.11 | 0.13 | 0.11 | 0.13 | 0.09 | 0.12 | 0.11 | 0.12 | 0.12 | 0.10 |
| San Francisco, CA | 0.23 | 0.22 | 0.22 | 0.22 | 0.23 | 0.24 | 0.22 | 0.22 | 0.24 | 0.23 | 0.23 | 0.16 | 0.24 | 0.24 | 0.21 | 0.24 |
| Boulder, CO | 0.06 | 0.06 | 0.05 | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.06 | 0.08 | 0.05 | 0.07 | 0.06 | 0.07 | 0.08 | 0.07 |
| Eagle County, CO | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.06 | 0.08 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Pueblo, CO | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 | 0.06 | 0.08 | 0.06 | 0.07 | 0.07 | 0.07 | 0.08 | 0.07 |
| Bridgeport, CT | 0.11 | 0.08 | 0.10 | 0.08 | 0.12 | 0.11 | 0.12 | 0.14 | 0.12 | 0.10 | 0.11 | 0.14 | 0.13 | 0.13 | 0.12 | 0.13 |
| Wilmington, DE | 0.06 | 0.09 | 0.07 | 0.09 | 0.11 | 0.06 | 0.10 | 0.13 | 0.06 | 0.13 | 0.05 | 0.08 | 0.08 | 0.08 | 0.12 | 0.08 |
| Miami, FL | 0.07 | 0.06 | 0.06 | 0.06 | 0.09 | 0.06 | 0.08 | 0.10 | 0.07 | 0.08 | 0.07 | 0.09 | 0.08 | 0.08 | 0.08 | 0.11 |
| Tampa, FL | 0.07 | 0.06 | 0.06 | 0.07 | 0.09 | 0.07 | 0.08 | 0.10 | 0.08 | 0.09 | 0.06 | 0.09 | 0.08 | 0.09 | 0.09 | 0.09 |
| Atlanta, GA | 0.09 | 0.08 | 0.10 | 0.10 | 0.11 | 0.10 | 0.09 | 0.12 | 0.10 | 0.12 | 0.09 | 0.14 | 0.11 | 0.11 | 0.10 | 0.11 |
| Savannah, GA | 0.09 | 0.08 | 0.09 | 0.10 | 0.11 | 0.10 | 0.09 | 0.11 | 0.10 | 0.11 | 0.09 | 0.13 | 0.11 | 0.11 | 0.10 | 0.11 |
| Des Moines, IA | 0.07 | 0.03 | 0.02 | 0.03 | 0.03 | 0.07 | 0.03 | 0.05 | 0.07 | 0.04 | 0.07 | 0.07 | 0.07 | 0.07 | 0.04 | 0.07 |
| Mason, IA | 0.07 | 0.03 | 0.02 | 0.03 | 0.03 | 0.07 | 0.03 | 0.04 | 0.07 | 0.04 | 0.07 | 0.07 | 0.07 | 0.07 | 0.04 | 0.07 |
| Boise, ID | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.06 | 0.05 | 0.05 | 0.04 | 0.05 |
| Chicago, IL | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Springfield, IL | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Indianapolis, IN | 0.09 | 0.08 | 0.07 | 0.09 | 0.09 | 0.08 | 0.09 | 0.11 | 0.08 | 0.11 | 0.07 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Goodland, KS | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Wichita, KS | 0.06 | 0.05 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Lexington, KY | 0.06 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.07 | 0.09 | 0.06 | 0.03 | 0.09 | 0.08 | 0.08 | 0.06 | 0.08 |
| New Orleans, LA | 0.04 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.02 | 0.03 | 0.04 | 0.02 | 0.03 | 0.08 | 0.04 | 0.04 | 0.02 | 0.04 |
| Shreveport, LA | 0.04 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 | 0.08 | 0.04 | 0.04 | 0.02 | 0.04 |
| Boston, MA | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |

| Location | Full-Service Restaurant | Hospital | Large Hotel | Large Office | Medium Office | Mid-Rise Apartment | Out Patient | Primary School | Quick-Service Restaurant | Secondary School | Small Hotel | Small Office | Standalone Retail | Strip Mall | Supermarket | Warehouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baltimore, MD | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Caribou, ME | 0.09 | 0.09 | 0.08 | 0.10 | 0.10 | 0.09 | 0.10 | 0.12 | 0.09 | 0.12 | 0.09 | 0.07 | 0.10 | 0.11 | 0.12 | 0.10 |
| Portland, ME | 0.11 | 0.10 | 0.09 | 0.10 | 0.11 | 0.09 | 0.11 | 0.13 | 0.11 | 0.13 | 0.09 | 0.07 | 0.12 | 0.12 | 0.14 | 0.11 |
| Detroit, MI | 0.08 | 0.08 | 0.08 | 0.09 | 0.12 | 0.09 | 0.08 | 0.11 | 0.08 | 0.10 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 |
| Houghton-Lake, MI | 0.08 | 0.08 | 0.08 | 0.09 | 0.12 | 0.09 | 0.08 | 0.10 | 0.08 | 0.10 | 0.08 | 0.09 | 0.09 | 0.09 | 0.08 | 0.10 |
| Traverse City, MI | 0.08 | 0.08 | 0.08 | 0.09 | 0.12 | 0.09 | 0.08 | 0.09 | 0.08 | 0.10 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 |
| International Falls, MN | 0.07 | 0.07 | 0.06 | 0.07 | 0.09 | 0.06 | 0.07 | 0.09 | 0.07 | 0.09 | 0.06 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 |
| Minneapolis, MN | 0.07 | 0.07 | 0.06 | 0.07 | 0.09 | 0.06 | 0.08 | 0.09 | 0.07 | 0.08 | 0.06 | 0.09 | 0.08 | 0.07 | 0.08 | 0.08 |
| Kansas City, MO | 0.09 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 | 0.10 | 0.09 | 0.09 |
| Jackson, MS | 0.06 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 |
| Billings, MT | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Greensboro, NC | 0.07 | 0.06 | 0.06 | 0.07 | 0.07 | 0.06 | 0.08 | 0.10 | 0.06 | 0.10 | 0.06 | 0.09 | 0.08 | 0.09 | 0.08 | 0.08 |
| Wilmington, NC | 0.07 | 0.06 | 0.06 | 0.07 | 0.08 | 0.06 | 0.07 | 0.09 | 0.06 | 0.09 | 0.06 | 0.08 | 0.09 | 0.08 | 0.08 | 0.08 |
| Bismarck, ND | 0.07 | 0.07 | 0.06 | 0.08 | 0.09 | 0.07 | 0.09 | 0.10 | 0.08 | 0.11 | 0.06 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 |
| Minot, ND | 0.08 | 0.08 | 0.06 | 0.08 | 0.09 | 0.08 | 0.09 | 0.11 | 0.08 | 0.11 | 0.06 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 |
| Omaha, NE | 0.05 | 0.04 | 0.05 | 0.05 | 0.06 | 0.05 | 0.06 | 0.06 | 0.08 | 0.07 | 0.05 | 0.09 | 0.06 | 0.06 | 0.06 | 0.06 |
| Concord, NH | 0.11 | 0.11 | 0.10 | 0.11 | 0.12 | 0.11 | 0.12 | 0.13 | 0.12 | 0.13 | 0.11 | 0.13 | 0.12 | 0.12 | 0.13 | 0.12 |
| Atlantic City, NJ | 0.10 | 0.11 | 0.10 | 0.11 | 0.12 | 0.09 | 0.11 | 0.13 | 0.11 | 0.12 | 0.09 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 |
| Albuquerque, NM | 0.12 | 0.09 | 0.12 | 0.09 | 0.13 | 0.12 | 0.13 | 0.14 | 0.17 | 0.11 | 0.12 | 0.16 | 0.13 | 0.13 | 0.13 | 0.13 |
| Las Vegas, NV | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.07 | 0.07 | 0.08 | 0.07 | 0.08 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Reno, NV | 0.07 | 0.07 | 0.06 | 0.07 | 0.08 | 0.07 | 0.08 | 0.09 | 0.07 | 0.09 | 0.07 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 |
| New York, NY | 0.09 | 0.05 | 0.09 | 0.06 | 0.12 | 0.11 | 0.09 | 0.16 | 0.08 | 0.16 | 0.09 | 0.11 | 0.12 | 0.12 | 0.15 | 0.13 |
| Rochester, NY | 0.09 | 0.06 | 0.09 | 0.05 | 0.12 | 0.11 | 0.09 | 0.20 | 0.08 | 0.17 | 0.09 | 0.14 | 0.12 | 0.12 | 0.15 | 0.12 |
| Syracuse, NY | 0.09 | 0.05 | 0.09 | 0.06 | 0.12 | 0.11 | 0.09 | 0.17 | 0.08 | 0.16 | 0.09 | 0.14 | 0.12 | 0.12 | 0.14 | 0.12 |
| Cleveland, OH | 0.08 | 0.09 | 0.07 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.11 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Oklahoma City, OK | 0.07 | 0.05 | 0.05 | 0.05 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Burns, OR | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.06 | 0.02 | 0.07 | 0.07 | 0.06 | 0.07 |
| Portland, OR | 0.07 | 0.05 | 0.05 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 | 0.06 | 0.08 | 0.06 | 0.02 | 0.07 | 0.07 | 0.07 | 0.07 |
| Philadelphia, PA | 0.08 | 0.09 | 0.08 | 0.09 | 0.09 | 0.08 | 0.09 | 0.10 | 0.08 | 0.10 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| Pittsburgh, PA | 0.09 | 0.09 | 0.08 | 0.09 | 0.09 | 0.08 | 0.09 | 0.10 | 0.08 | 0.11 | 0.08 | 0.10 | 0.09 | 0.09 | 0.10 | 0.09 |
| Providence, RI | 0.05 | 0.07 | 0.07 | 0.07 | 0.07 | 0.05 | 0.08 | 0.08 | 0.05 | 0.08 | 0.05 | 0.06 | 0.05 | 0.05 | 0.08 | 0.05 |
| Charleston, SC | 0.14 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.13 | 0.16 | 0.16 | 0.14 | 0.13 | 0.16 | 0.14 | 0.14 | 0.14 | 0.15 |
| Pierre, SD | 0.10 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.08 | 0.08 | 0.10 | 0.08 | 0.09 | 0.11 | 0.10 | 0.10 | 0.08 | 0.10 |

| Location | Full-Service Restaurant | Hospital | Large Hotel | Large Office | Medium Office | Mid-Rise Apartment | Out Patient | Primary School | Quick-Service Restaurant | Secondary School | Small Hotel | Small Office | Standalone Retail | Strip Mall | Supermarket | Warehouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Memphis, TN | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Nashville, TN | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Amarillo, TX | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 |
| El Paso, TX | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 |
| Houston, TX | 0.07 | 0.05 | 0.04 | 0.05 | 0.08 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.06 | 0.08 | 0.07 | 0.07 | 0.07 | 0.08 |
| Cedar City, UT | 0.05 | 0.05 | 0.04 | 0.06 | 0.06 | 0.04 | 0.06 | 0.08 | 0.06 | 0.07 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Salt Lake City, UT | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.04 | 0.06 | 0.07 | 0.06 | 0.07 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Richmond, VA | 0.07 | 0.03 | 0.01 | 0.03 | 0.07 | 0.07 | 0.07 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| Burlington, VT | 0.11 | 0.10 | 0.09 | 0.11 | 0.11 | 0.12 | 0.10 | 0.13 | 0.12 | 0.13 | 0.10 | 0.15 | 0.11 | 0.12 | 0.12 | 0.12 |
| Seattle, WA | 0.09 | 0.08 | 0.07 | 0.09 | 0.08 | 0.09 | 0.08 | 0.09 | 0.10 | 0.10 | 0.08 | 0.10 | 0.09 | 0.09 | 0.08 | 0.09 |
| Yakima, WA | 0.09 | 0.08 | 0.07 | 0.08 | 0.08 | 0.09 | 0.08 | 0.09 | 0.10 | 0.09 | 0.08 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 |
| Green Bay, WI | 0.15 | 0.15 | 0.15 | 0.14 | 0.15 | 0.15 | 0.14 | 0.14 | 0.15 | 0.14 | 0.15 | 0.15 | 0.13 | 0.13 | 0.14 | 0.15 |
| Charleston, WV | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 | 0.14 | 0.08 | 0.06 | 0.14 | 0.07 | 0.07 | 0.07 | 0.07 |
| Elkins, WV | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 | 0.14 | 0.08 | 0.06 | 0.14 | 0.07 | 0.07 | 0.07 | 0.07 |
| Cheyenne, WY | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.06 | 0.06 | 0.04 | 0.06 | 0.05 | 0.05 | 0.06 | 0.05 |

# Appendix C: Digital Appendix

The digital appendix includes detailed charts and tables for each location, building type, and rate structure evaluated.

http://en.openei.org/wiki/Impact_of_Utility_Rates_on_PV_Economics_-_Digital_Appendix