



Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges

SUMMARY

This paper presents the first publicly available comprehensive survey of the magnitude of demand charges for commercial customers across the United States—a key predictor of the financial performance of behind-the-meter

battery storage systems. Notably, it is estimated that there are nearly 5 million commercial customers in the United States who can subscribe to retail electricity tariffs that have demand charges in excess of \$15 per kilowatt (kW), over a quarter of the 18 million commercial customers in total in the United States.¹ While the economic viability of installing battery energy storage must be determined on a case-by-case basis, high demand charges are often cited as a critical factor in battery project economics.² Increasing use of demand charges in utility tariffs and anticipated future declines in storage costs may also serve to unlock additional markets and strengthen existing ones.

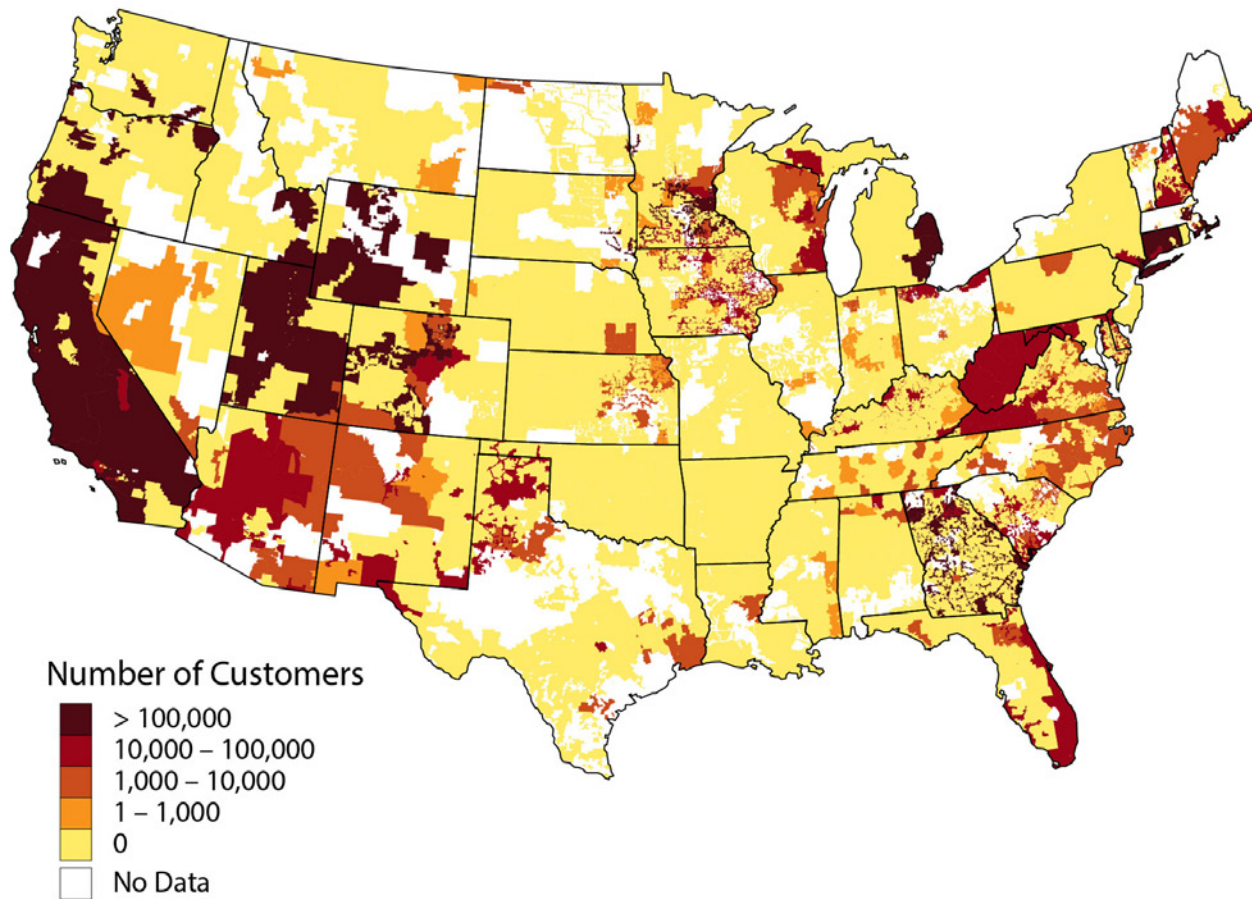


Figure 1. Number of commercial electricity customers who can subscribe to tariffs with demand charges in excess of \$15/kW.

This effort is the first to undertake such an extensive review of utility rates. The analysis is based on a survey of more than 10,000 utility tariffs, which are available to approximately 70% of commercial buildings in the United States. The types of customers that are covered by the tariffs analyzed in this study are diverse and include private and nonprofit businesses, community facilities, public buildings, and multifamily housing properties, all of which commonly have demand charges in their utility tariffs. The contribution of demand charges varies from customer to customer, but typically ranges from 30%–70% of the customer’s electric bill.³

Noteworthy findings include:

- High demand charges and storage market opportunities exist outside of first-mover states like California and New York. There are potentially economic cases for storage in the Midwest, Mid-Atlantic, and Southeast regions of the country.
- Some of the country’s highest demand charges were found to be in states not typically known for high electricity prices, such as Colorado, Nebraska, Arizona, and Georgia.

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- States identified as having the most commercial customers facing demand charges of \$20/kW or higher represent a diversity of locations across the country, from Georgia and Alabama in the South, to Michigan and Iowa in the Midwest, to New Mexico and Texas in the Southwest.

IDENTIFYING LOCATIONS WITH HIGH DEMAND CHARGES

From grocery stores to apartment buildings to hospitals, thousands of commercial customers small and large are already investing in technologies like solar photovoltaics (PV) to cut energy costs and advance sustainability goals. While it is relatively easy for customers with simple, energy-only tariffs to calculate the potential for cost reductions from solar PV, commercial tariffs commonly have another component that adds complexity to the financial equation: demand charges.

Nearly all medium and large commercial customers in every state have the option of subscribing to a tariff that includes a demand charge, yet few customers understand how these charges are structured or how they impact electricity costs. Additionally, information about the range of utility demand charge rates is not commonly compiled and reported on. As shown in Figure 2, demand charge rates vary widely across the country, and can even vary greatly between neighboring utility territories within the same state.

What are Demand Charges?

Demand charges are designed as a way for utilities to recover costs associated with providing sufficient electricity generation and distribution capacity to their customers. By basing a portion of a customer’s electricity bill on their peak level of demand, the utility distributes more of the costs associated with building and maintaining system capacity to those who contribute most to the need for increased capacity.

Demand charges are typically based on the highest average electricity usage occurring within a defined time interval (usually 15 minutes) during a billing period. Unlike electricity consumption charges, which account for the volume (kWh) of electricity consumed throughout a billing period, demand charges track the highest rate (kW) of electricity consumption during the billing period. The greater the need for electricity at any time during the period, the higher the customer’s demand.

Demand charge rates vary considerably across utilities, locations, building sizes, and building types. Because the charges are based on the way in which each customer uses electricity, even two customers that consume similar amounts of electricity and are billed under the same utility rate may incur vastly different demand charge expenses. Despite the fact that demand charges often represent from 30%–70% of a commercial electric bill, many customers do not fully understand how demand is measured and billed.

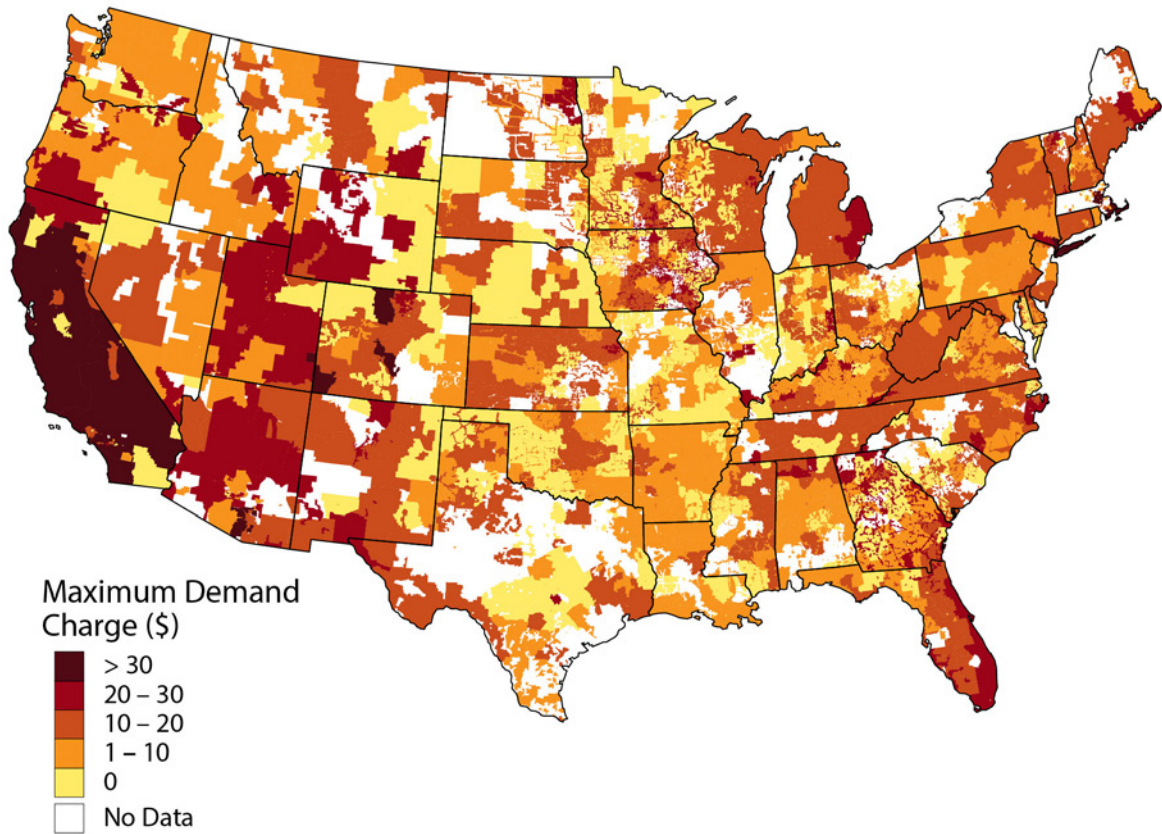


Figure 2. Maximum demand charge rates by utility service territory.

Demand Charges Can Vary Widely, Even Within the Same State

Table 1 illustrates just how significant these variations can be for customers within a state. In New York, for instance, a customer on Long Island may be paying demand charges of more than \$50/kW, but the average maximum demand charge for utilities within the state is less than \$10/kW. Similarly, a business in Atlanta may see nearly \$30/kW demand charges, while more than half of utilities in Georgia have a maximum demand charge of less than \$4/kW. These disparities reflect both differences in the rate design process—which varies by utility—as well as differences in the costs they are reflecting. For example, maintenance of distribution infrastructure is significantly more expensive on Long Island than it is in rural New York.

Both solar and battery storage technologies have the potential to reduce demand charges. However, because demand charges are typically assessed based on a customer’s maximum demand during the given month, a few clouds at the wrong time have the potential to mostly

Table 1. Summary of Demand Charges for the States with the Highest Utility Demand Charge Rates in the Country

Demand Charges Across All Utilities Operating in the State			
	Maximum charge across all utilities	Average of all utility maximum charges	Median of all utility maximum charges
New York	\$51.25	\$9.30	\$4.30
California	\$47.08	\$11.45	\$10.60
Colorado	\$46.43	\$21.68	\$16.65
Massachusetts	\$41.25	\$19.14	\$15.50
Arizona	\$35.45	\$18.82	\$18.50
Nebraska	\$30.00	\$14.82	\$15.70
Illinois	\$30.00	\$16.58	\$16.63
Georgia	\$28.70	\$5.83	\$3.60
North Carolina	\$25.65	\$15.61	\$15.63
Vermont	\$25.39	\$17.43	\$16.05

eliminate any solar-enabled demand reduction savings for an entire billing period.⁴ Storage, on the other hand, can more reliably deliver demand reductions throughout a billing cycle. In an integrated solar-plus-storage system, the technologies can often complement each other and increase demand charge savings through an effective demand-management strategy. Where the extra cost is warranted, additional hardware can also be installed that allows the system to complement traditional backup generation as part of an islandable microgrid to provide backup power during a grid outage.

SUMMARY OF METHODOLOGY

Using publicly available data, analysts estimated the number of commercial customers that would be eligible for a utility tariff in which demand charges exceed various thresholds. A set of electricity load profiles was generated for 10 commercial building types, using the U.S. Department of Energy Commercial Reference Buildings,⁵ covering each ASHRAE climate zone in the United States.⁶ The proportion of each building type was held constant across utility territories, according to its occurrence in the national building stock.⁷

The authors then curated a set of more than 10,000 available commercial utility tariffs from the Utility Rate Database.⁸ The list included utility tariffs available to approximately 70% of the commercial electric load in the lower 48 states. Based on location and building characteristics, the authors determined which of the representative building load profiles would be eligible to subscribe to each utility tariff in the set. NREL then identified the fraction of buildings eligible to subscribe to a tariff with demand charges above certain cost thresholds—for example, the fraction of buildings eligible for a demand charge of \$15/kW or higher.

Finally, for utilities for which customer count data was available, NREL multiplied the fractional building results by the number of commercial customers to estimate the number of customers exceeding defined thresholds. To summarize the results by state, the results for each utility territory were assigned to one or more states based on the fraction of the utility's customers located in each state.⁹ Each of these steps is summarized in Figure 3.

Method Used to Estimate Number of Demand Charge Customers

Step 1:
Generate load profiles for commercial buildings across the U.S.

Generate a set of representative energy use profiles for 10 common commercial building types for each of the U.S. climate zones. Assign each profile a weight to indicate how prevalent it is across the country.

Step 2:
Identify demand charge tariffs and potential subscribers

Develop a list of commercial utility tariffs across the country. Based on location and energy use characteristics of the building profiles, determine which of the utility rates each building type is eligible to subscribe to. Determine the fraction of buildings in each utility territory that could subscribe to at least one tariff with a demand charge above certain thresholds.

Step 3:
Estimate number of possible customers with a demand charge above a threshold

Apply the fraction of buildings eligible for a demand charge rate to the commercial customer count for each utility. This yields an estimate of the number of customers who would be eligible to subscribe to a demand charge above a certain threshold. To summarize the data by states, based on the fraction of customers served in each state.

Figure 3. Summary of the methodology used to estimate how many commercial customers may be eligible for utility tariffs that include demand charge rates at or above specific cost thresholds.

MILLIONS OF CUSTOMERS HAVE THE OPTION OF SUBSCRIBING TO TARIFFS WITH MODERATE TO HIGH DEMAND CHARGES

This section presents the results of an analysis of more than 10,000 electricity rate tariffs across the continental United States, to determine the prevalence and magnitude of demand charges applicable to commercial customers. In addition, the analysis evaluates hundreds of building energy load profiles to estimate the number of customers in each territory that may be subject to specific demand-charge cost thresholds. This not only identifies regions where there may be an economic case for behind-the-

meter battery storage investment, but also provides an indication of the potential size of the market for storage across these regions. These results are intended to help visualize the variation in demand charges across the country, and to help identify new market opportunities for companies offering storage or solar-plus-storage technologies.

Figure 1 (page 1) shows the geographical distribution of approximately 5 million commercial customers who are currently eligible for electricity tariffs with a demand charge rate of at least \$15/kW. This represents more than a quarter of the 18 million total commercial customers in the United States. Although the financial performance of a behind-the-meter battery is influenced by numerous customer-specific factors, a separate NREL analysis found that high demand charges are a predictor of the financial viability of batteries, and Greentech Media analysis suggests \$15/kW as a notable threshold.² It is important to note that this is an estimate of the number of customers with the option of subscribing to a tariff with the given demand charge level—not an estimate of the actual number of customers on such tariffs. Furthermore,

not all electricity usage patterns are a good fit for storage. Nonetheless, this does represent a significant potential market opportunity for storage technologies.

Table 2. Top 10 States with the Most Commercial Customers Estimated to be Eligible for Utility Rates That Include Demand Charges of \$15/kW or Higher

	Number of Customers Eligible for Demand Charge >\$15/kW
California	1,420,000
New York	648,000
Georgia	237,000
Colorado	221,000
Michigan	209,000
Massachusetts	189,000
Texas	155,000
Connecticut	135,000
Minnesota	134,000
Ohio	124,000

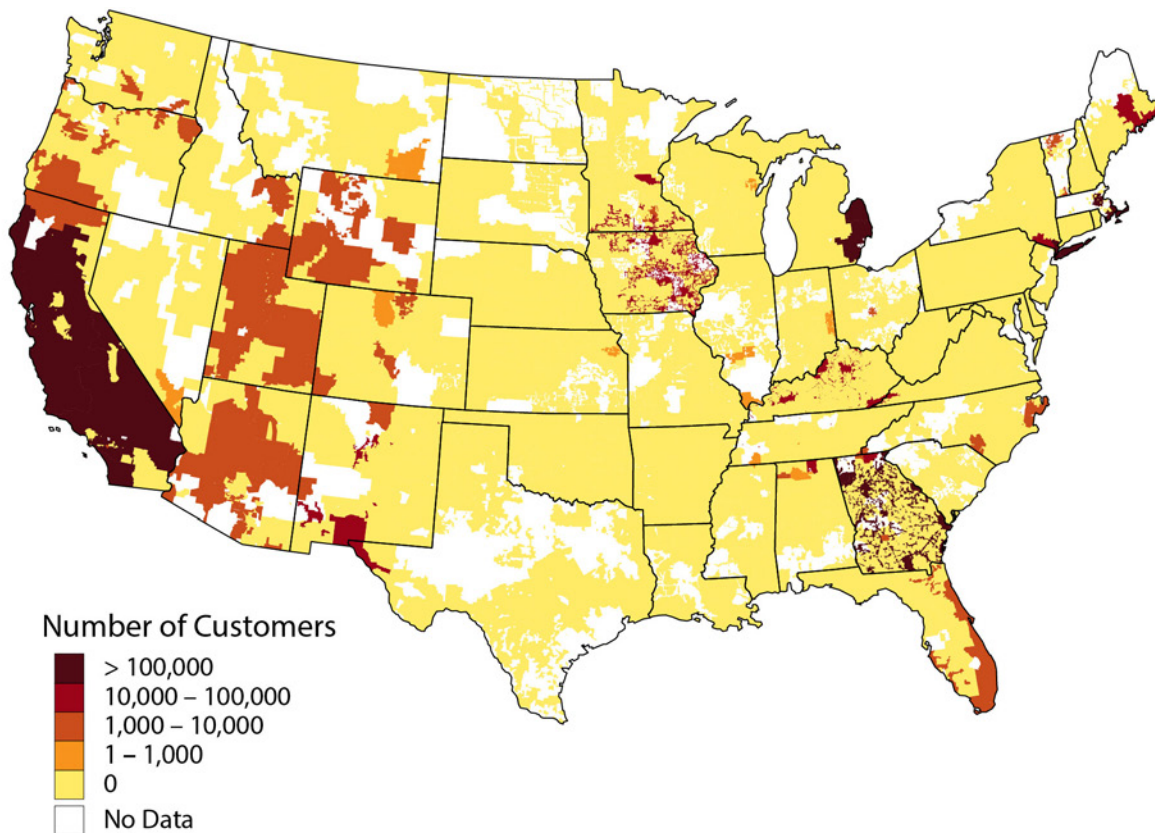


Figure 4. Estimated number of commercial electricity customers who can subscribe to tariffs with demand charges in excess of \$20/kW.

Many customers may assume that investing in emerging technologies like battery storage would only be cost effective in locations with historically high electricity prices; however, the analysis uncovered potential opportunities for storage deployment in nearly every state. Table 2 lists the top 10 market opportunities at the \$15/kW threshold by the number of eligible commercial customers located in each state. As expected, California and New York top the list, but the rest of the top-ranking states represent a wide diversity of locations from around country: Connecticut and Massachusetts in the Northeast, Colorado in the West, Michigan and Ohio in the Midwest, and perhaps most surprisingly, Georgia in the Southeast. Many additional states were found to have tens of thousands of customers that may have moderate to high demand charges, as shown in Figure 1.

Figure 4 and Table 3 expand on the economic picture by looking at customers potentially facing demand charges of at least \$20/kW. The \$20 demand charge threshold represents about 3 million commercial customers—about 15% of all commercial customers. Customers falling into this rate class would have an even greater economic incentive to explore battery storage for demand management and greater potential for electricity cost reductions.

Table 3. Top 10 States with the Most Commercial Customers Estimated to be Eligible for Utility Rates That Include Demand Charges of \$20/kW or Higher

	Number of Customers Eligible for Demand Charge >\$20/kW
California	1,081,000
New York	648,000
Georgia	216,000
Michigan	205,000
Massachusetts	180,000
Kentucky	41,000
New Mexico	24,000
Alabama	23,000
Texas	23,000
Iowa	23,000

While California and New York still dominate the list of top state markets at or above the \$20 threshold in Table 3, there are still some surprises. Georgia and Michigan take the spots for the third and fourth largest market rankings, with followed by Massachusetts and Kentucky. Again, there are pockets of high demand charges in a variety of regions across the country.

FUTURE OPPORTUNITIES AND NEXT STEPS

As with solar, battery storage costs have experienced a rapid decline over the past few years and are projected to prompt a reduction in demand charge rates, potentially stagnating, or even decreasing, the number of financially motivated customers. If there is no significant change in the structure of electricity tariffs, declining battery costs will continue to increase the number of customers who can financially benefit from behind-the-meter energy storage. On one hand, customers with demand charges of no more than \$10/kW or less may find that battery storage has become a cost-effective measure to reduce electricity demand expenses within several years (today, that would represent a potential market opportunity of more than 6 million customers). On the other hand, a world with such low storage costs may alter the bulk power system sufficiently to prompt a reduction in demand charge rates, potentially keeping the number of financially motivated customers constant or even decreasing.

The analysis presented here offers a snapshot of where moderate to high demand charge rates are located and how many customers may subscribe to them. This provides an indication of where market opportunities may exist for battery storage and solar with storage to provide cost savings through demand charge reduction. Based on the findings, the opportunities may be broad, but further on-the-ground effort is necessary to identify which specific customers have siting and energy consumption patterns that make them good candidates for behind-the-meter storage.

ENDNOTES, REFERENCES, AND RESOURCES

(1) It is important to note that this is an estimate of the number of customers who have the option of subscribing to a tariff with the given demand charge level—not an estimate of the number of customers who are actually on such tariffs. Often, commercial customers have more than one tariff they are able to subscribe to. The one with the highest demand

charge may not be the most suitable option for a particular customer, although the option of low-cost storage may prompt some customers to choose high-demand-charge tariffs when they otherwise might avoid them.

(2) A statistical analysis of techno-economic optimization modeling results conducted at NREL found that, of the variables studied, peak demand charges were the most significant predictor of an economically viable battery. [Long, M.; Simpkins, T; Cutler, D; and Anderson, K. “A Statistical Analysis of the Economic Drivers of Battery Energy Storage in Commercial Buildings.” 2016: <http://www.nrel.gov/docs/fy17osti/66832.pdf>] In an analysis of rate structures across 51 utilities, Greentech Media Research found that implementing 1-hour and 2-hour duration storage systems for demand charge management begins to make economic sense at a demand charge rate of at least \$15/kW. [Greentech Media. “Commercial Energy Storage Economics Will Be Attractive in 19 US State Markets by 2021.” July 13, 2016: <https://www.greentechmedia.com/articles/read/commercial-energy-storage-economics-will-be-attractive-in-19-us-state-marke>] The consulting firm McKinsey & Company found even more favorable results for energy storage, determining that some customers could break even by investing in energy storage at a demand charge rate of about \$9/kW. [D’Aprile, P., Newman, J., and Pinner, D. “The New Economics of Energy Storage.” August 2016: <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage>]

(3) This is a commonly referenced range; for example, see: <http://www.stem.com/resources/learning/> <http://www.mosaicenergy.com/2017/06/03/understanding-utility-demand-charges/> <https://www.fs.fed.us/t-d/pubs/htmlpubs/htm00712373/> <http://www.poweroptions.org/resources/faqs/>

(4) Darghouth, N.; Barbose, G.; Mills, A.; Wiser, R.; Gagnon, P.; Bird, L. “Exploring Demand Charge Savings from Commercial Solar.” Lawrence Berkeley National Laboratory, 2017: <https://emp.lbl.gov/publications/exploring-demand-charge-savings-0/>

(5) Commercial Reference Buildings: <https://energy.gov/eere/buildings/commercial-reference-buildings>

(6) ASHRAE Climate Zones: https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/4_3a_ba_innov_buildingscienceclimatemaps_011713.pdf

(7) Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey (CBECS) Data, Tables B1 and B7: <https://www.eia.gov/consumption/commercial/data/2012/>

(8) Utility Rate Database: <http://en.openei.org/apps/USURDB/>

(9) Energy Information Administration Form 861: <https://www.eia.gov/electricity/data/eia861/>

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Learn more at: <http://resilient-power.org>

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