ABSTRACT

In the early days of electricity generation utility service areas were small. When another house was added to the utility service area, additional electricity generation capacity had to be installed to meet the new demand. New and existing utility customers were required to pay a fee to cover the costs of this additional generation infrastructure. But nowadays, utilities can forecast service demand with great precision, and thus do not need to add additional generation capacity to meet the power demands of existing businesses. In fact, synchronous generators can instantaneously respond to changes in load up to their capacity. Yet utility customers still pay demand charges. Demand charges unfairly penalize power produced from solar.

This paper addresses the history of demand charges and uses examples of measures businesses do to reduce or eliminate demand charges. There is growing pressure on utilities to modernize demand charges. Repeated analyses show that businesses are often placed on an unfitting utility rate. A simple rate analysis can demonstrate that a business can use another utility rate without demand charges. Rate analysis finds numerous instances where commercial customers fall well below the threshold of utility demand charges, yet the utility continued to charge the customer for demand charges. The use of newly available and inexpensive automated energy monitoring equipment can keep the business attuned to its power demands. Relatively easy methods of managing power demand such as staging lighting and motors, along with cycling AC loads, can reduce demand charges. The paper presentation summarizes demand charges, especially in relation to on-site solar; makes a case for their modernization, while offering methods to reduce them now.

1. INTRODUCTION: HISTORY OF DEMAND CHARGES

One hundred years ago utility service areas were sometimes only a few city blocks in size. Peak power requirements came in the early evening when people came home from work and turned on their lights. At this time lighting was typically the only electricity loads that homes had, and a customer's full power use was often assessed from the number of connected light bulbs. When another house was added to the utility service area, additional utility electricity generation capacity had to be installed to meet the new demand. New and existing utility customers were required to pay a fee to cover the costs of this additional generation.

In the later part of the 19th Century and early part of the 20th Century, as electricity was becoming a household service, there was an international discussion about how electricity should be priced to users. The British engineer John Hopkinson was the first electrical engineer to depict the electricity demand charge as a tool to split a utility's fixed costs among its customers. Hopkinson made the
argument that peak load was a substantial component of the overall costs of running a power plant. However, Hopkinson then made the conclusion that it was accurate to charge electricity customers based on their individual peaks rather than on their electricity use during system peaks, thus the Hopkinson rate came about.

The Hopkinson rate sets a demand charge, such as $/month/kW of the maximum demand in the month (usually during a 15 minute period), plus an energy charge of often less than $/kWh used in the month. At the time (late 1800s and early 1900s) electricity rates and meter technology were developing, most of the larger users of electricity had their own isolated onsite power generation. In 1900 about two-thirds of all of the electricity used was self-generated rather than purchased from a utility. Almost all of this onsite power generation was done by manufacturing facilities. By 1930, when many major urban utilities had expanded and come into prominence, the percent of total electricity used that was generated onsite had declined to about one-third (1).

The timing of the large-scale adoption of demand charges coincided with the rise of major electric utilities and the beginning of state regulation of the electrical industry. And, whether through design and/or circumstances, the demand charge was used as a means of discounting the price of electricity to onsite power customers, and thus discouraging existing onsite generation facilities from continued operation as well as discouraging other manufacturers from constructing onsite facilities. As utilities grew in size and scope, some of the advantages of onsite power generation diminished, while economies of scale increased for the major utilities.

It is important to note that at the time the Hopkinson demand charge rate was widely adopted, there was minor dissimilarity between the time of the utility system peak and the time of individual users' peaks. Utilities can now forecast individual service demand with great precision, and thus do not need to add additional generation capacity to meet the power demands of an additional business. The fact remains that one hundred years ago demand charges were used to discriminate against on-site (isolated) power generation. And 100 years later this is still the case with on-site solar power generation (2). The next section addresses how utilities undervalue on-site solar.

2. HOW DEMAND CHARGES DISINCENTIVIZE SOLAR

As noted, either through design and/or circumstances, the fact remains that demand charges now penalize commercial onsite solar customers. There are several additional dimensions to how onsite solar is now at a disadvantage. First, onsite solar is generally produced during peak load periods for utilities. Utilities usually pay a premium for the additional peak power requirements during this time, typically midday. However, solar is rarely recognized as a source of premium power. Utilities refer to solar as being “infirm” power, because of its intermittent nature. Nonetheless, solar production can be predicted with a fairly high level of accuracy (3).

Power generation is generally comprised of base load power plants, intermediary generation and peaking power generation. Base load power generation usually consists of coal fired power plants, nuclear plants, and traditional hydroelectric. These are power generation assets that have lower generation costs and higher capacity factors. Intermediate power generation is often comprised of older, costlier coal plants, and some lower cost natural gas generation. Peaking power is usually natural gas generation that can be brought on-line and off-line quickly according to peak power demands.

In addition, utilities rarely recognize (let alone monetize) the value that onsite solar generation brings in the form of reducing costs associated with central generation and distribution. Fewer resources are required to deliver the same power onsite. Thus, there are distributions savings, transmission savings, generation savings, fixed operation and maintenance savings, and fuel, purchased power and losses savings that are all experienced by the utility when there is onsite solar power generation. There are now numerous studies to better quantify these benefits to the utility. Hourly day-ahead power prices at peak times have recently been as high as $.35/kWh. Yet, the solar energy produced by onsite solar at that time on a commercial demand charge rate is often valued at less than $.05/kWh (4). The next section considers several different rates.

3. COMMERICAL RATE ANALYSIS AND SOLAR

There are four primary categories of rates for Xcel Energy business customers in Colorado. These categories, among other factors, determine the voltage at which the electric service is delivered. The customer or electrical engineer (new construction) usually decides which type of service and rate structure is required based on the energy requirements of the business. Normally, there is minimal analysis completed for businesses in order to determine which type of rate is most cost-effective.

Most Xcel Energy small business customers with less than 25 kW demand are on the Commercial or “C” rate, and the bulk of Xcel Energy Commercial and Industrial customers with greater than 25 kW demand are on the
Secondary General or “SG” rate. The Xcel Energy SG, SGL, PG and TG rates all have Time-of-Use consumption requirements. Beginning in 2011 the time-of-use rate is voluntary for the SG and SGL rate but required for the PG and TG rates. The on-peak times are 9am to 9PM on weekdays except for holidays. The off-peak periods are 9pm to 9am weekdays, including holidays and weekends. There are also other variations for the Xcel Energy rates such as Photovoltaic Time of Use (PVTOU) rates and interruptible rates. This study looks at C, SGL, SG, and PVTOU rates (6).

The Xcel Energy Commercial or Schedule “C” Rate is applicable to customers whose demands are less than 25 kW for electric power service supplied at secondary distribution voltage. All kilowatt-hours used, per kWh are Summer Season $0.06450, and Winter Season $0.03920. The effective rate including multipliers is about $0.085 – $0.11/kWh. Generally, the Xcel Energy Schedule C is friendlier to customers, as long as the energy produced by the solar for the customer amounts to at least 30-40% (or more) of the total annual energy requirements for that facility (6). (Table 1)

The Xcel Energy Schedule “SGL” Rate is applicable to electric power service supplied at secondary distribution voltage at above 25kW Demand. The Demand Charge for the SGL Rate is $4.84/kW, and the Energy Charge is $0.10-$0.14. The effective rate for the Schedule SGL is $.18-.22. The customer must have a low load factor (~10-12% or less) for the SGL rate to be cost effective. The electric service load factor is the ratio of the average load in kilowatts supplied during a designated period to the peak or maximum load in kilowatts occurring in that period. Load factor can be calculated by multiplying the kilowatt-hours (kWh) in the period by 100 and dividing by the product of the maximum demand in kilowatts and the number of hours in the period. For example, to calculate load factor = kWh/hours in period/kW. If there is a 30-day billing period, there is 30 times 24 hours for a total of 720 hours. There is a customer who uses 10,000 kWh and has a maximum kW demand of 21 kW. Thus, the customer’s load factor would be 66 percent ((10,000 kWh/720 hours/21 kW)*100). In the case of the Xcel Energy Schedule SGL, the “Low Load Factor” usually has to be 10-12% or less. Although Xcel Energy seems to makes this unclear. Generally, the SGL Rate is also friendlier to solar, again as long as the solar energy produced can cover 30-40% (or more) of the overall energy requirements of the facility. (6)

The Xcel Energy Schedule SG is one the least friendly Xcel Energy rates to solar. It is a very common rate for small business in Colorado. The SG Rate is also applicable to electric power service supplied at secondary voltage. Distribution Demand is $4.84, while Generation and Transmission Demand - Summer Season is $10.96, and Generation and Transmission Demand - Winter Season is $8.00. The SG Rate Energy Charge is $0.00473. However, the effective energy rate is $0.04 - $0.06. This is the Xcel rate which poses the most difficulty for Xcel Energy customers. Some Xcel Energy SG customers can change to the PVTOU rate. However, the customers must have a minimum load factor of 30%, and for the PVTOU Rate to be effective for the customer the solar must provide 40 plus percent of the energy requirements for the facility (Table 2) (6).

The PVTOU Rate can be used by residential, commercial and industrial customers whose electric service is using an on-site solar system operated in parallel with Xcel Energy. For PV systems connected to a single-phase electric service, the total generation capacity, including the PV system, cannot exceed 20 kilowatts.” The PVTOU Rate capacity is limited each year. For 2012 there is only 1 MW available in 2012 (6). The next several sections give examples of how utility demand charges disadvantage solar customers, and how these disadvantages were overcome.

4. CASE STUDY ONE: RETAIL CARPET CENTER

Carpet Time is a large retail facility with a 4,500 ft2 office, and large vaulted and lit showroom/storage facility with 12,320 ft2. This facility exhibits typical electrical consumption behavior of similar facilities. The load is relatively constant from 7am-5pm. Previous to the solar installation and a lighting upgrade, this facility was regularly reaching 30-34 kW for peak demand and 6,800-10,400 kWh of usage per month. As a consequence of the demands greater than 25 kW, this facility was originally on an Xcel Energy SG (secondary general) utility rate, with about 2/3 of the electric bill coming from demand charges and fees.

In order for this solar installation to have the greatest impact, it was necessary to decrease the peak demand by 25% to keep it below the 25kW threshold. This was accomplished by performing a lighting upgrade, and by suggesting run the electric forklift charger after-hours. After these upgrades were performed, the facility usage peaks at ~22 kW. A 25 kW PV system was installed and we have observed the PV system to cover a large portion of the peak demand, and 60% of the usage. The facility was switched to the C rate (commercial rate), and the electric bill has decreased 75%-80%, and the REC payments cover the remaining portion of the bill (Fig1).

5. CASE STUDY TWO: HISTORICAL CHURCH
The First Baptist Church is a house of worship built in 1912. Similar to most churches, the facility has a low load factor and high spikes of usage on Sundays or other gatherings. This facility was originally on the SG utility rate. This facility was regularly reaching 18-28 kW for peak demand and 2,500-5,000 kWh of usage per month. In order to increase the payback for the PV system, various energy efficiency upgrades were performed intended to get the facility on a C rate. This included a lighting system upgrade, HVAC upgrades that increased pumping efficiency. A large portion of the success of this project was attributed to educating the staff, and installing a monitor that would allow them to adjust their electricity usage based on demand (Fig. 2).

After the efficiency upgrades, the facility usage dropped by 20%-25%. The peak demand can still be above 25 kW on Sundays, but thus far the solar keeps the demand seen by the utility well below 25 kW. The 25 kW system and the efficiency upgrades cover 75%-80%% of the bill and the REC payments give the church a modest cash flow.

6. CASE STUDY THREE: SMALL WOODWORK SHOP

Conifer Products is a 3200 ft2 woodworking facility that manufacturers Newel Post Mounting Systems for residential and commercial installation. Conifer Products ships products all over the US and Canada. Through 2008 and 2009 Conifer products was on an Xcel Energy SG rate with kW demand staying around 35 kW. In the fall of 2009 a 10kW PV system was installed onsite and began to produce 1000-1200kWh per month for the facility. The solar was providing about half of the kWh needed for the facility after it was installed, although only the overall electric bill by 10-15%. The demand charges on the Xcel Energy SG Rate were still substantial (Figs. 3 & 4).

Thus the challenge became how to reduce or eliminate the demand charges. Through interviews and energy analysis, it was discovered that Conifer Products was operating a molding machine which has 5 electric motors, roughly 30kW in total. The owner initially was able to change the facility from Xcel Energy SG Rate to the Low Load SGL. This was possible because the load factor for the facility was ~11%. This change cut the demand charges in half and gave the customer twice the value for the energy the solar produced. Eventually, the customer was able to switch yet again to the Xcel Energy C Rate and eliminate the demand charges altogether. The PV now covers a proportionate amount of the energy charges +/- 50%.

In the design, installation, and operation of small to medium size (10-100kW) PV systems for commercial customers over the last 5-6 years in Western Colorado, it became clear that no matter how well the PV system was designed, and how well the PV system produced energy, there are institutionalized rate barriers to the PV system providing proper compensation to the owner for the energy generated. Customers become frustrated as they witness their PV systems producing well, while the utility provides them with disproportionately low compensation for the solar energy produced.

And in researching the history of utility demand charges it became clear that the utilities have put in place several means of disenfranchising onsite power generation for over 100 years. The Hopkinson Rate and similar such rates have long been used to discourage customers from using onsite power generation. So from a practical standpoint, the authors had to find real-world solutions to uncovering greater value for the solar PV systems. Thus, it is critical to do detailed facility energy analysis in order to find the greater value for the solar. In doing this, it is discovered that, in numerous instances, the utility maintains the commercial customer on an ill-fitting and more expensive rate (sometimes for years), notwithstanding the addition of any solar. Fairly simple analysis often proves that with a few minor modifications, the commercial customer can use another better fitting rate and find substantial savings. AES created the Rate Analysis Tool in order to examine different Xcel Energy rates in relation to the on-site solar (Table 2).

Minor modifications, reasonable upgrades, and sometimes simply calling the utility to switch the rate often produces excellent savings, all the while making the onsite solar energy produced much more effective and valuable. These are all important solutions, and it is incumbent upon any facility owner to do his or her best to realize greater efficiency, comfort, and savings form their operations.

However, longer term solutions must also include different, fairer, rate structures for solar onsite power generation. These longer-term technical and policy solutions include greater use of time-of-use rates, tiered pricing, and better compensation to the solar customers for the value that the solar adds to the overall well-being of the electricity grid and all ratepayers.
FIG. 1: A typical cloudless day. Note that the solar peak corresponds to the facility peak.

Fig 2: A Saturday and a Sunday usage and solar data. Note that the net demand seen by the utility is well below the 25 KW limit because of concurrent solar production.
Fig. 3: Billed demand before and after solar.

Fig. 4: Total kWh usage per month before and after solar.
REFERENCES


TABLE 1: XCEL ENERGY RATES

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TABLE 2: AES RATE ANALYSIS TOOL

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