# More Value to Metering Than Ever Before

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## ABSTRACT

While custom utility efficiency programs routinely employ metering to bolster analysis and verify energy savings on large projects, site metered data seldom gets used for other purposes. But there are additional, highly valuable metering benefits to both the end user as well as the utility. For one, metered data can assist with constructing modernized load and savings shapes for a variety of end-uses. These exceedingly outdated shapes are a component of many utilities' screening tests used to determine measure cost-effectiveness. Furthermore, using metered data to update these shapes can greatly assist utilities with capacity planning even as a large percentage of energy load growth is being met through efficiency. Metering can also benefit an industrial customer who is required to pay demand charges. Efficiency upgrades can have a twofold benefit to their bottom line, and metered data can help validate energy as well as capacity savings. By highlighting the many benefits to metering this paper aims to explore the following:

- Perceived value of metering in utility programs from customer and utility perspectives
- Reasons why updated load and savings shapes have been ignored for so long
- Examples from the field of updated shapes and their impacts

Key takeaways for the reader/audience will be to:

- Understand how demand savings are quantified to the utility and end-user
- Compare several load and savings shapes based on recent metered data
- Recognize the importance of demand reduction from a utility perspective

## Introduction

Many custom energy efficiency programs that engage one-on-one with customer sites routinely need to determine the particular characteristics of a site before proceeding with an in-depth energy analysis. Depending on the complexity of the equipment involved or the uniqueness of the operations at the site, some programs may choose to install metering equipment to obtain detailed information about existing system energy consumption or confirm hours of operation. Meters provide a means to get reliable data that cannot always be gathered by facility staff interviews and engineering assumptions alone. The value that metering data provides to an end-user and the energy efficiency program is often obvious and immediate. Even if data logging equipment is left in place for a standard 2-week metering cycle, energy consumption information about the existing systems can often be established, load hours of operation can be tracked, and an annual energy use profile can be developed. Reliable metering information also helps to promote the value of an efficiency project to an end-user. The efficiency program benefits because the analysis is based on actual metered data and will likely evaluate well. The end-user benefits because the magnitude of savings are often accurate enough that securing financial capital can be done with high confidence to move a project forward.

But there are benefits of metering beyond simply the energy savings analysis, both to the end-user and the efficiency program, as well as to regional planning entities. This paper will explore the various ways in which metering is employed and how the results are used by various interested parties. It will describe the benefits from the perspective of the end-user, the analyst and efficiency program, and the regional planner and will offer insights into metering benefits through past experiences. Finally, this paper will promote the advantages that can be realized from obtaining metered data during the post installation period as part of a Measurement and Verification (M&V) phase by using real examples from the field.

## Why Meter In The First Place?

In a typical custom efficiency program design, where energy analysis is often times based on the unique circumstances of a particular site, getting an understanding of how the facility operates is key to providing a sound energy analysis. For large commercial and industrial end-users, obtaining specific equipment and site parameters is critical to understanding elements such as facility operation schedules, power consumption, load shapes, and energy savings potential. Often times a talk with a facility operations staff can reveal much about how the systems tend to operate on a daily basis, any recent renovation history, and which nuanced elements of the energy analysis should be targeted based on what they know about the equipment. These talks are invaluable and should not be overlooked, even if a wealth of data exists from controls systems or sub-meters throughout the site. However, despite the benefit that knowledgeable operations staff can bring to a project, there are certain aspects of system operation that cannot be identified through conversations alone.

For many sites, the use of metering equipment in the pre-conditions case[1] is vital to fully understanding the equipment operation and energy savings potential. Installing a meter that measures true power to an end-use can do more than simply provide the analyst with a way to obtain representative average power consumption measurements. It can alert them to operational inconsistencies with stated facility occupancy schedules (ex. lighting left on over the weekend when facility is unoccupied), point to an operational problem within a system (ex. motor being operated outside of its service factor rating), and allow an owner to gain insight into power usage on a system or component level rather than having it rolled up at the utility meter. In all these cases metering, even for a small window of time, can identify operational characteristics that may not be apparent to even the most knowledgeable facility staff.

Aside from the value that metering provides to the analyst conducting the study and the end-user who is poised to gain insight from the findings, installing metering equipment prior to efficiency improvements has other benefits depending on how long the logging equipment is permitted to remain in place. Although two weeks is industry standard for obtaining a representative estimate of load hours of operation and baseline energy consumption, there are disadvantages to this short metering period and clear benefits from metering for longer when possible. Table 1 below lists three periods at which metering equipment may commonly be installed, along with some of the potential benefits and drawbacks depending on the metering duration employed.

[1] The pre-conditions case is defined here as the period of time before an efficiency project has been implemented.

Table 1. Metering Installation Period Comparison

| Metering Period | Benefits | Drawbacks |
|---|---|---|
| 2 weeks minimum | - Able to obtain reasonable assumption of facility load hours and weekly consumption data<br><br>- Establishes an actual measured baseline from which to calculate energy savings potential<br><br>- Can uncover immediate operational issues that longer trend data doesn't provide additional information about | - Not representative of annual usage if operations schedules shift throughout the year<br><br>- Certain elements of equipment (or plant) may be down for repair and not captured in consumption estimates<br><br>- Depending on time of year, it may be difficult to accurately capture seasonality effects in equipment that rely heavily on changing weather conditions<br><br>- Setpoint changes, either manual or scheduled, may not be evident |
| Longer than 2 weeks, but less than 1 year | - Better representation of operation schedules and equipment usage patterns<br><br>- Able to capture weather impacts on equipment operation more accurately given a wider spread in weather patterns | - Longer metering period leaves customer on the hook for financial decision-making until the data can be analyzed<br><br>- May still incorrectly capture equipment and plant operation schedules depending on seasonality and weather patterns |
| 1 year minimum (or longer) | - Representative of energy use for an entire year<br><br>- Likely to capture seasonality for both equipment operation and occupancy as well as weather dependent equipment | - Not viable for many sites looking to quantify efficiency savings and awaiting incentive payments to make investment decisions<br><br>- Investment in long-term metering equipment not viable for most utility programs, and additional benefits may not exist compared to shorter term metering |

Another benefit to installing metering equipment, regardless of duration, is the wealth of information and insight it can lend to other projects where metering may not be feasible. Understanding the nuances of motor startup power draw, compressor sequencing under varying load conditions, or common scheduling errors that occur in a control system is information that has value beyond a single site analysis. Building a repository of metered data and common operating characteristics has significant benefit to the analyst and efficiency program who will likely come across similar efficiency opportunities at other sites. In addition, many facilities commonly implement efficiency measures at different points in time, and spending the extra effort to characterize operations through detailed metering will lead to less effort being required on subsequent projects at the same site once operations are more thoroughly understood.

## Sub-metering OR Whole Site Metering?

While metering at the sub-component level is important for many industrial sites that have unique processes and for which any component being analyzed may be difficult to isolate from a whole building meter, obtaining utility meter data can still be helpful and should not be ignored. The increased availability of interval meter data (i.e. site energy use data in increments smaller than monthly) provides a way to study historic energy use profiles to look for inconsistencies in scheduling and changes in large energy consuming devices. Whereas sub-metered data can provide the energy analyst and end-user with detailed information about the operating characteristics of a single piece of equipment, whole site interval level meter data can be beneficial to understanding the operation of that equipment over a longer period of time. Coupling interval meter data with short-term metering data is the most beneficial and should be used when relying on shorter metering periods (such as two weeks) to check consumption during that time period against annual data to ensure the metering period was representative.

An example of where interval level data proved to be beneficial all on its own is shown in Figure 1 below. In this instance, ½ hour interval data at the utility meter for a school over a typical year indicated that holidays and summer school hours were not being scheduled for the HVAC and lighting systems. The systems were all found to be operating on a year-round schedule as evidenced by the afternoon energy use being relatively constant throughout the year. Furthermore, nighttime energy use was observed to be at a higher than anticipated level given the mix of equipment operating after occupied hours. Investigating the cause showed that custodial staff was leaving lighting systems on for most of the night thus causing the elevated level of electricity consumption.

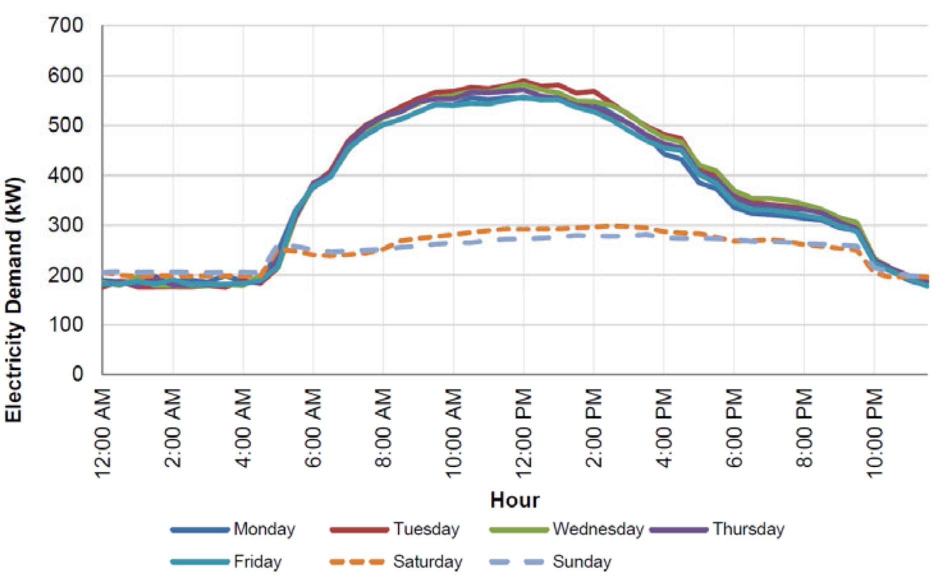


Figure 1. Utility Meter Interval Data – Average Energy Use Profile for 2012 School Year by Day of Week. *Source*: Confidential Client, 2012.

While obtaining interval level data of historical energy use is sufficient for certain cases, acquiring sub-metered data at the time of analysis is often times more important. This is necessary when interval data is only able to provide granularity at the hour or sub-hourly level, when in fact more granular data is necessary to truly understand the operational characteristics. Take the example of a plant which used a single 800 HP motor to run a wood chipper. An estimate of energy consumption could be made using motor nameplate data and the hours of plant operation. However logging found that the existing motor was operating well into its service factor rating, exhibiting the power consumption of a 1200 HP motor. The site also assumed that their peak demand was occurring at start-up of the motor, and planned to replace it with two 600 HP motors with staggered starts to reduce their peak demand charge. Power logging was performed at 1-second intervals to understand the consumption of the motors during start-up and chipping. Due to this highly granular logging, it was discovered that peak demand was instead occurring during chipping and not startup, as demonstrated below in Figures 2 and 3.

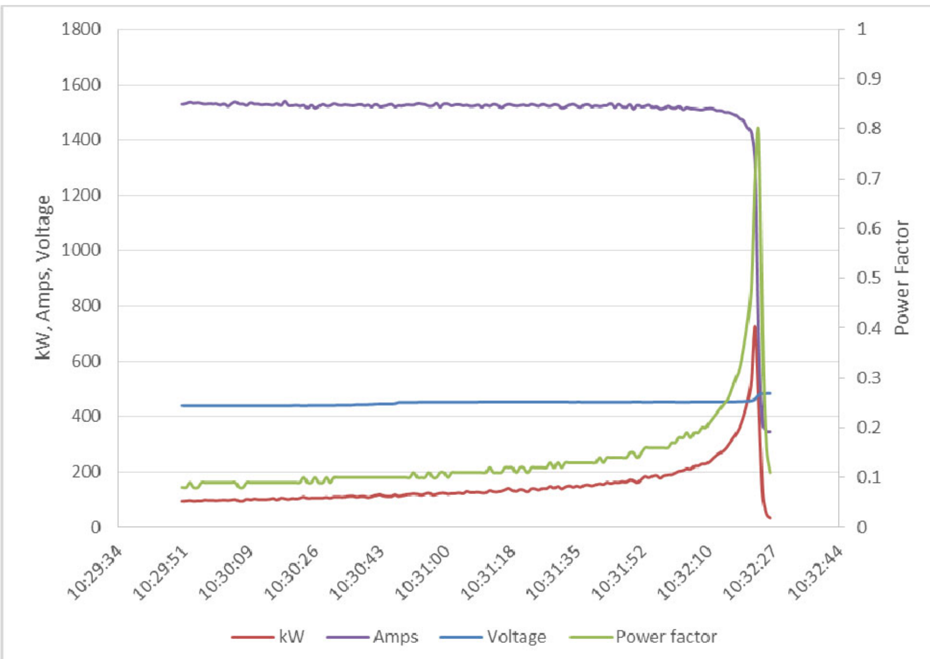


Figure 2. Chipper Motor Power during Startup. *Source*: Confidential Client, 2014.

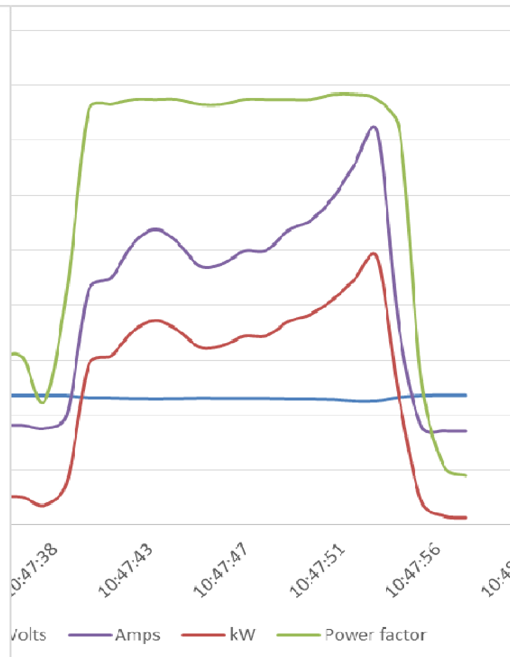


Figure 3. Chipper Motor Power during Chipping. *Source*: Confidential Client, 2014.

Providing the end-user with this level of information would not be possible if sub-metering was not utilized on the site. Relying on utility meter data, even at a sub-hourly interval level, would only confirm that a large demand load was taking place due to the chipper motor, but not precisely when it was occurring. In the end, purchasing two 600 HP motors would be a large capital investment for the site and would not alleviate the large demand charges on their utility bill. Moreover the energy savings estimated by the analyst using nameplate data for the motor would be incorrect due to the increased motor power consumption, thereby leaving savings unclaimed to the program and a potentially low realization rate in the evaluation.

## So Why Not Meter In The First Place?

While metering can provide many benefits to the end-user, as well as the energy analyst and efficiency program, instances do exist where installing metering equipment is either not warranted or advisable. There are several common barriers to installing metering equipment in the pre-conditions case, and they are often the result of unique site circumstances rather than the upfront cost or a customer's unwillingness to participate in the exercise.

A typical barrier occurs on sites that require continuous operation, which is often the case in the industrial sector. When looking at gas efficiency measures on a site that operates continuously, installing a gas flow meter to measure baseline consumption is expensive, time consuming, and not viable for maintaining the required plant operation. In this case, requiring the facility to shut down to install a meter is a cost that the end-user is not likely to incur, especially when no perceived value yet exists. Similarly on the electrical side, performing a live installation on high voltage equipment is not likely to be performed by efficiency program staff in the field. Since safety is of primary concern, often times this leads to requiring an electrician being available on site to install metering equipment. While this may be the case for large industrial plants that have such professional services available on-call, not all sites have similar access to these services. Likewise, not all efficiency program operators have access to the varied metering equipment necessary for each site. Leaving data loggers in place for several weeks is likely to lead to either fewer projects receiving metering, or a larger up-front cost to procure multiple loggers. Although the site may be advised to invest in metering equipment of their own, this often results in a case of Catch-22 where the facility is likely to want to understand the value of procuring metering equipment, and that value can't be readily explained in the absence of metered data that provides insight into their processes.

There are other cases where metering is not warranted, either due to minimal savings potential, or where operations are well understood already. In these cases, the time and effort required to install loggers and analyze the data is likely greater than the benefit received from obtaining that data. In these cases, the end-user could still benefit from the insight gained into their operations through metered processes, however efficiency programs are less likely to bear the cost of metering if they believe savings are reliably quantifiable already.

So what alternatives exist to obtain reliable site specific information in the absence of metering? Commonly, utility programs are forced to make assumptions in these cases and often times those assumptions can be made based on prior analysis of similar equipment or operations. This is where the benefit of metering at other sites pays dividends, because a more reliable estimate of consumption and operation can be obtained based on the knowledge of past projects. While each site is unique, and very few savings analysis are reproducible between industrial facilities, understanding operating characteristics of similar equipment is certainly beneficial to understanding potential issues that could arise.

Still, given the many benefits of metering to both the end-user and the energy analyst, every attempt should be made, at a minimum, to obtain utility level interval data and, if possible, sub-metering data when individual system level operation is crucial to assessing energy consumption and overall savings potential.

## Wait, You're Telling Me We Should Meter Again?

Installing sub-meters in the pre-conditions case is sometimes not viable in situations due to the specialized conditions of a site, access to equipment and electrical panels, or the timeframe in which to reliably install metering equipment and analyze the data. Regardless of whether the availability exists to perform metering during the pre-conditions case, metering during the Measurement and Verification (M&V) period provides both a means to validate assumptions and realize expected savings as well as to potentially generate additional savings. This additional benefit can be seen in cases where M&V has been performed on a site even after the efficiency project had been commissioned. In the following example, a new energy efficient chiller was installed at a site, and commissioning was performed to ensure the as-built condition was operating as specified. Because meters were able to be installed during this M&V phase, the operating profile of the chiller over a varying range of condenser temperatures could be seen. Analyzing the logged data showed that the expected kw/ton was higher than anticipated in the savings analysis. Here is a critical fork in the road for the program administrator and their M&V consultant. Do we reduce the claimed savings to what was actually measured, or analyze the M&V data and equipment operation to improve performance and gain additional savings? We chose the latter and a simple correction to the controls logic lowered the chiller kw/ton to the expected range and the project was able to realize the full savings potential. Figure 4 below highlights the difference between the two conditions which would not have been possible had the metering not been available in the M&V phase of the project. The key lesson learned here is that M&V can be much more than a way to true-up energy savings. It can be a tool to better commission a project and realize additional energy savings.

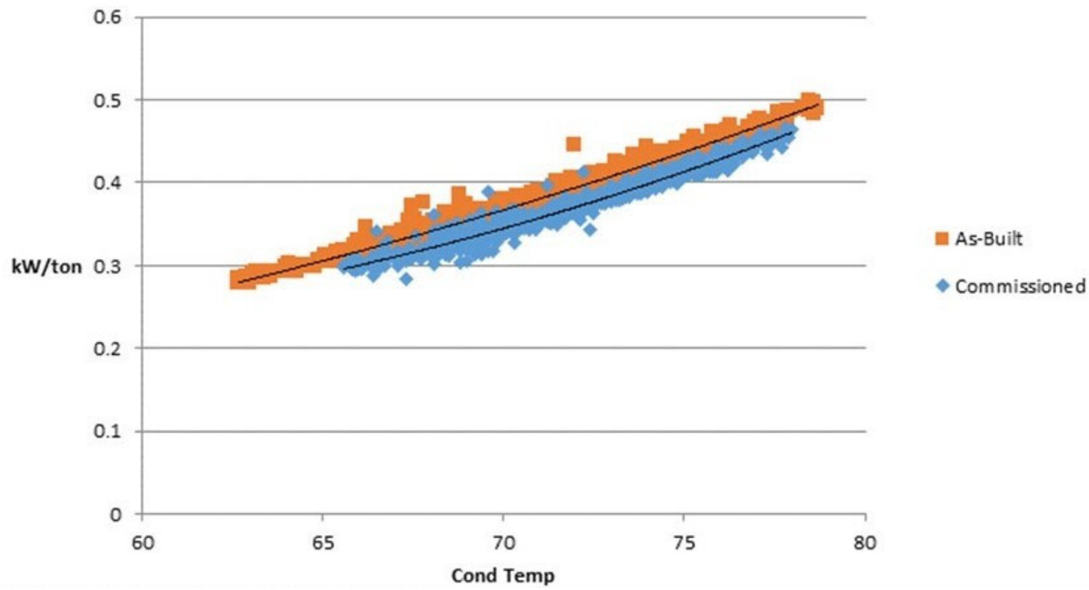


Figure 4. Chiller Performance Data. *Source*: Confidential Client, 2014.

Post-installation metering is one way in which true value can be delivered to the end-user, and accountability over savings claims can be carried by the efficiency program. Data found during an M&V phase lends credence to future evaluations when efficiency programs can point to validated post-installation data to show that savings were accurately realized. Furthermore, metering that remains in place during the post-installation phase, either by the efficiency program or by the end-user, can also be used to validate the persistence of savings, which is an aspect of energy efficiency that is becoming increasingly important due to more and more industrial efficiency measures focusing on operational and behavioral changes and less on one-for-one equipment change-outs.

## In Summary: Increased Value All Around

Once specific data is analyzed, both the end-user and the efficiency program are able to realize increased value from a metering effort. The savings analysis and report that is delivered to the client, which is now based on measured site specific data, provides a reliable way to communicate the actual effect of efficiency upgrades to the end-user. When post project metering is able to identify further commissioning opportunity and glean additional energy savings, both the end-user and the program administrator benefit greatly. Furthermore, when you consider that at this point in the process, the cost of the upgrades has already been borne, the increased savings achieved by M&V and associated commissioning are extremely cost effective.

### Increased Value To The End-User

An end-user will typically receive the savings report detailing the metering findings and recommendations for efficiency improvements. Many end-users appreciate the ability to see data from individual processes to know how their equipment is operating and possibly where to focus efficiency efforts down the road. While data from this effort is often used to close the deal on an ongoing project, it can also be a valuable reference to site owners and operators about where energy use is occurring and the importance of efficient operations that affect their bottom line. In the earlier example regarding the wood chipper motor, future motor change-outs at this site can benefit from the knowledge gained on a single metering project, and alleviate the risk of spending capital budget on planned upgrades where cost savings may not be realized.

### Increased Value To The Utility Program

Following on the theme of increased information being made available to end-users, those projects which rely on metering are more likely to realize actual savings on the utility bill. Moreover, these customers may be likely to follow-up on subsequent projects with the efficiency program if the value of the first project can be realized. Metering also provides the efficiency program with a greater chance of high savings realization rates[2]. This effect is of primary concern for many programs and helps justify future funding to continue efficiency work.

### Increased Value To The Regional Planner And The Importance Of Load Shapes

When metering is used to determine energy use profiles on site, it does more than provide a benefit to the end-user and utility program operator. Metering offers a broader benefit by obtaining load and savings shape information which is used by regional planners, as well as many utility efficiency programs to quantify the effect that efficiency measures have at reducing or eliminating a particular end-use on the power generation system. The results of efficiency measure demand savings on these loads are an important aspect of grid reliability. As regions of the grid become more capacity constrained, understanding when major loads typically occur throughout the day, week, month and year becomes increasingly important to ensuring that the grid remains reliable. A primary concern is that data collected from the last major end-use study is nearly three decades old, yet it is still being referenced to assign value to efficiency in terms of capacity reduction on the grid.

The last large data collection effort to characterize end-use load shapes was completed in the late 1980’s. The End-Use Load and Consumer Assessment Program (ELCAP) study was one of the largest efforts ever enacted to obtain residential and commercial load and savings shapes, and has served as the preeminent source for load shape information for the nation for over 30

[2] Realization rates are given as the ratio of estimated savings to actual savings, with 100% being a target value.

years. It involved the collection of hourly end-use electricity consumption data along with detailed characteristics from approximately 100 commercial buildings and 400 residences in the Pacific Northwest over several years. Smaller efforts have emerged in recent years to help capture additional end-uses, but none on the scale of ELCAP and typically not focused on the significant end-uses of the industrial sector. Although fewer overall sites exist in the industrial sector compared to other sectors, demand loads can be substantial, and insight into load shapes for common end-uses would benefit those tasked with studying grid reliability.

It is likely that current load shapes differ from historical load shapes, even if little data exists currently to support this theory. There have been significant changes with various end-uses that are likely to have altered both the end-use shape as well as the savings shape from implementing measures aimed at reducing power consumption. Several significant changes in function and performance for common equipment have occurred since the ELCAP data collection effort conducted long ago:

- **Heating Ventilation and Air Conditioning** – Federal standards have been enacted that significantly increase the minimum performance requirements of HVAC equipment and market changes have introduced units with better part load performance characteristics.
- **Lighting** – Lighting standards for ballasts and fluorescent tubes have undergone several changes since the 1980's, and many manufacturers have begun to push out inefficient lighting technologies that were previously used in retrofit markets.
- **Motors** – Federal standards for general purpose motors did not exist during the previous end-use study, and new standards in place since 2010 have significantly reduced the energy use and peak demand of motors.

Experts agree that continuing to use the same ELCAP load shapes to characterize load contributions to the grid is increasingly risky. The annual investment decisions impacted by end-use load shapes are in the hundreds of millions of dollars, therefore a significantly "wrong" decision can expose the grid to billions of dollars of risk. An example of this can be seen with the case study presented earlier related to the wood chipping facility. Average and peak demand load estimates used for the lumber and wood products industrial sector (SIC code 24) are shown in Figure 5 below and reflect the current understanding of demand for that service industry. Comparing the peak demand of Figure 5 with the peak demand witnessed in Figures 2 & 3, one can see that it is about 1/3 of what the actual peak on the system was during the metering period. Whether this plant is representative of the industry, or simply an anomaly is not known due to the lack of comparative data. However it brings to light a potential discrepancy in the data currently being used to generate load shapes compared to what is actually occurring in the field.

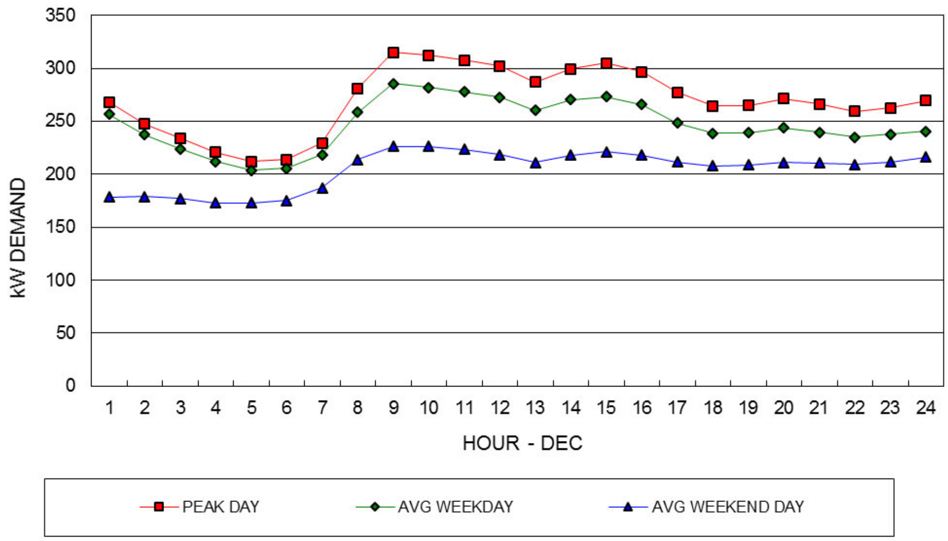


Figure 5. Annual Load Shape for SIC Code 24. *Source*: NW Power and Conservation Council

## Why Is Metering More Valuable Now Than Ever Before?

The value that metering provides is disseminated among a variety of interested parties, not just the end-user that receives a savings analysis that is custom tailored to their site. For the efficiency program, metering that leads to successful projects and realized savings can help encourage follow-through on future efficiency projects at a facility. Since time was taken to obtain detailed information up front, the efficiency program benefits over time from a lower cost per site as additional projects are implemented. In addition, providing end-users with insight into their operations allows them to target areas that could benefit from further study, as well as enable the initial savings to persist for longer periods. Furthermore, using M&V as a mechanism to better commission efficiency projects will lead to highly cost-effective incremental savings for both end-users and program administrators.

The gathering of load shape and savings shape information to provide regional planners with more insight would greatly help increase the benefit of efficiency as it is compared to other generation sources. It would also provide utility load forecasters with better insight into the effect that efficiency can have on the capacity constrained aspects of the grid.

Because policies are now in place and metering technology has advanced in recent years to keep data acquisition high and costs low, obtaining sub-metered and interval level meter data is poised to become more common.

## In Conclusion

As noted above, the benefits of metering are numerous, and the barriers to conducting even short-term metering are few. Communicating the benefits of metering to interested parties is one of the next challenges in the ongoing effort to reduce wasted energy consumption. Furthermore, the more informed utility resource acquisition programs are about energy and demand use, the greater impact they can have on reducing consumption. The deeper insight end-users have about their energy use and waste, the more in-focus the financial benefits of efficiency appear. Metering provides in-depth knowledge of energy use and allows both the end-user, and ultimately ratepayers who commonly funds energy efficiency programs, to benefit.

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