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# Conducting a metering assessment to identify submetering needs at a manufacturing facility

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ABSTRACT

Submetering the energy consumption of processes, systems, or equipment at a manufacturing facility can provide insight into the energy efficiency and productivity of its operations. With the growth of the "Big Data" market and increasing number of submetering options, collecting data is not a challenge; collecting data that can result in actionable information leading to energy savings is a challenge. Further, as manufacturing is in the midst of the smart manufacturing and industrial analytics revolution, developing optimal submetering strategies is of increasing importance, especially if submeters are being installed as a retrofit to an existing facility/process. In particular, small to midsized manufacturing (SMM) facilities will require technical assistance to fully avail of submeter data and join the smart manufacturing revolution.

This paper presents a metering assessment as a method to identify the optimal use of submeters and applications of the collected data at a manufacturing facility. The metering assessment consists of temporarily submetering energy uses to identify future metering needs. The metering assessment involves gathering data on an energy use(s) over a finite length of time, conducting analysis of the data to better understand energy consumption characteristics of the energy uses, and developing an optimal permanent submetering strategy. Through the metering assessment, a facility can better identify uses for submetered data before installing permanent submeters, thereby limiting the collection of extraneous data. Further, the facility can avail of smart manufacturing opportunities by installing submeters as a retrofit and using the collected energy data to inform operational decisions in real-time.

The benefits of conducting a metering assessment are presented using an example from a SMM metal tube manufacturing facility. The results from a metering assessment conducted at the facility resolved outstanding operational issues while also identifying where permanent submetering could improve productivity. Through applying the metering assessment at an SMM facility and identifying uses of submeter data, this paper illustrates the type of technical assistance required to bring the benefits of smart manufacturing and industrial analytics to SMM facilities.



## Introduction

Submetering within a manufacturing facility can be an effective method for monitoring and improving operations and reducing energy consumption. Submetering consists of measuring and collecting energy-related data of a process, system, or equipment at a regular interval. It is also at the center of the smart manufacturing and industrial analytics revolution. Smart manufacturing, as defined by the American Council for an Energy-Efficient Economy, is "the integration of all facets of manufacturing, regardless of level of automation, and all the individual units of an organization, for the purpose of achieving superior control and productivity" [1]. Submetering enables the integration and use of real-time energy data from various processes and systems to inform operational decisions and improve productivity.

The challenge with submetering is not in collecting energy-related data, but in empowering a manufacturing facility to use the data to make productivity and energy efficiency improvements. For example, in a survey conducted of manufacturers globally, industry identified the need for tools to manage production processes with respect to energy efficiency. Specifically, integrating real-time data

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from the facility floor to optimize energy efficiency and reduce energy consumption was identified as a need [2].

There are numerous potential uses of submeter data including improving energy efficiency, reducing energy consumption, and improving the productivity of a manufacturing facility. One example is early detection of system or equipment faults [3,4]. Another is non-intrusive load and energy efficiency monitoring [5]. Submeter data can also inform decisions on selecting the appropriate electric utility rate structure. As described by Wang and Li [6], the energy cost savings from switching from a flat-fee rate structure to a time-of-use structure will depend on the alignment between peak hours and production schedules [6]. Alignment can be ensured through the use of data collected from submeters to inform production planning.

Submeter data can also be used to monitor activity on the manufacturing facility floor. Vijayaraghavan and Dornfeld demonstrated the use of electric power data to identify events within a machine tool process, such as spindle start-up, changing spindle speeds, and idle periods. The authors have proposed a software framework that would support energy decision making by evaluating energy consumption and operational data from machine tools and identifying events within a manufacturing process [7]. Similar profiles could theoretically be developed for manufacturing equipment or processes to better understand its energy consumption characteristics and drive energy cost reductions and energy efficiency improvements [8–11, 20].

Submetering data can also be an integral part of a continual improvement-based energy management system (EnMS), such as ISO 50001 [12]. The EnMS establishes a structure, including processes supported by the necessary internal resources, to better understand energy consumption at a manufacturing facility through integration of data collection assets, such as data from submeters. As an example, data from metering systems is required to develop facility-specific energy performance metrics. In a case study at a biomedical facility, submetering was required to develop energy performance indicators specific to the facility's operations. The energy performance indicators supported by submetered data allowed for continuous monitoring of key energy uses, as well as benchmarking and continuous improvement in their energy efficiency. Monthly data collection or high-level performance indicators (i.e. energy consumption per unit of product) did not provide the temporal resolution or granularity required for continuous monitoring of key systems [13,14].

Strategies for integrating submeters and other data collection assets into an energy management system have been proposed [11,14,15]. Vikhorev et al. [11] suggest that connecting continuous measurement of energy data at the industrial process level to business performance can support raising "energy awareness", or insight into how energy use and consumption impacts business overall at the facility. The authors propose a strategy for an advanced energy management system that uses submeter data to identify events during production and calculate key performance indicators in real-time enabling data-driven operational decisions. The connection between energy consumption and units of productivity is central to understanding the energy performance of a facility. An optimal submetering strategy within the context of a continual improvement-based EnMS will both quantify energy consumption and provide insight into productivity.

These examples of using submeter data to drive real-time data driven decision making illustrate the role of submetering in transforming a traditional facility into a smart manufacturing facility. Smart manufacturing and industrial analytics are being seen as defining characteristics of the next industrial revolution. Pictures of robotic automobile assembly facilities are this revolution's icons. However, for small and medium manufacturing (SMM) facilities the challenges and opportunities are less grand but perhaps more important. Implementation of smart technologies must normally be done as a retrofit and proper analytics are different from facility to facility and even system to system. Additional challenges faced by SMM facilities to adopting smart manufacturing and making use of industrial analytics include: unavailability of staff resources to focus on energy considerations, short return on investment requirements for energy efficiency projects, and energy costs viewed as being fixed or sunk. Technical assistance in these areas is necessary to accelerate implementation. Thiede et al. [16] presented a methodology that incorporates data infrastructure and analytics into a continual improvement-based EnMS in a manner that is appropriate for SMM facilities. The authors identify several challenges to developing such a methodology including: (1) determining the correct frequency at which to collect data; (2) determining if permanent or single measurement is required and (3) developing a facility-specific methodology. The authors also stated that energy and production data should be integrated in a production management scheme.

In addition to identifying the best uses of the data and turning the data into actionable information, several obstacles emerge when deciding how best to implement submeters. Many are paradoxical in that they are difficult to resolve without collecting data. Facilities may be reluctant to finance metering installations because the resulting energy savings are difficult to predict. A survey conducted at 100 U.S.-based 3M manufacturing facilities identified gaining management approval, justifying costs, financial constraints, and unknown return on investment as barriers to installing submeters [17]. Further, identifying metering requirements including the type of meter to install, meter locations, and the frequency at which to collect data is a challenge. There are several metering options, and the selection of the appropriate meter will depend upon the end use to be metered, the desired accuracy, installation cost, sampling rate, intrusiveness, communications, and other characteristics [18]. Similarly, permanent submetering may not be required if temporary metering can resolve outstanding facility issues. Without overcoming these challenges to submetering, many facilities will be left out of the smart manufacturing revolution.

This paper presents a metering assessment as novel method to identify the optimal use of submeters and best uses of the data in a manufacturing facility. The metering assessment allows a facility to gain a better understanding of the value of data acquisition at a specific facility before installing permanent submeters. This improves on the common practice of installing permanent submeters without a "trial" period, and relying on generic information about manufacturing operations to determine submetering location, frequency, and applications of the resulting data. By conducting a metering assessment before installing permanent submeters, several challenges associated with installing permanent submetering can be addressed, including: developing financial justification for permanent submetering, developing a facility-specific permanent submetering protocol, and identifying if temporary or permanent submetering is required. Unlike other approaches, the approach presented here balances the need for collecting data within a facility, with practical considerations such as the ability to use the collected data to inform productivity and energy related decisions. Finally, the metering assessment allows for existing facilities to become "smart" through retrofitting submeters. The paper uses the example of an SMM facility to demonstrate the value of the metering assessment, including the type of technical assistance and data analysis required to bring the smart manufacturing revolution to SMM facilities.

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