# Measurement and Verification of Industrial Energy Conservation Projects

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ABSTRACT

Ontario Power Authority (OPA) is one of the key agencies to implement electricity conservation programs in Ontario, Canada. OPA is putting increasing emphasis on carrying out measurement and verification (M&V) for electricity conservation and demand-side management projects for all its incentive programs. This article discusses the measurement and verification carried out for some of those projects. The cases are taken from M&V reviews carried out for various industrial plants located in Ontario. The measurement and verification was part of the Building Owners and Managers Association (BOMA) Conservation and Demand Management (CDM) program, which was supported by the OPA.

As per the BOMA Toronto CDM incentive program, there was incentive for electricity conservation and demand reduction measures. The rigor of the M&V process required would vary depending on the electricity savings. Measures with savings less then 50 kW/400,000 kWh would fall in the *basic* category while measures more than 50 kW/400,000 kWh would fall in the *enhanced* category. Some of the M&Vs discussed in the article are implementation of a cooling water bypass pump in a cogeneration plant, lighting retrofit and lighting controls in a brewery, and implementation of compressed air controls from a coffee packaging facility. In many of these cases, Option A and Option B from the International Performance Measurement and Verification Protocol (IPMVP) guidelines are followed. Elements of the M&V plans are discussed. Some of the issues, like metering methods used for determining variation of electricity for different operating conditions, are highlighted. The benefits of the M&V process to all the stakeholders are also discussed.

## INTRODUCTION

The measurement and verification process can help in gaining support from all stake holders towards implementing a sustainable energy management program in an industrial facility. There are other benefits, such as increasing energy savings, enhancing financing for energy efficiency projects, and educating all facility users about their energy impacts. M&V is also an important component for the International Organization for Standardization (ISO) 50000 standard. From the perspective of the incentive program, the M&V process ensures that incentive dollars are used effectively to achieve the desired objective of reducing energy.

## ISSUES AND CHALLENGES

The resources (primarily skills) required to carry out the M&V process are limited. Some energy efficiency/conservation measures implemented in industries can be very complex and may require activities like process modeling and simulation to carry out M&V. Organizations like the Association of Energy Engineers (AEE) and the Efficiency Valuation Organization (EVO) are playing key roles in addressing the skill requirements in this area.

In Ontario, some of the incentive programs are putting increasing emphasis on the measurement and verification process. Such initiatives are helping in building capacity and the implementation of energy conservation/efficiency projects for major actors such as engineering consultants, energy managers, energy service companies, etc.

### BOMA CDM Review Process

The Building Owners and Managers Association (BOMA) Conservation and Demand (CDM) incentive program requires a third party review of the M&V plan for a proposed electricity and/or demand (kW) reduction project submitted by clients. The reviewer mandate is also to verify and/or assist in the execution of the M&V plan.

The following cases present experiences from the M&V review process.

*Case Study 1*

The first case is taken from a lighting retrofit project for a brewery. The project involved replacement of 400-watt metal halide lights with T5 banks, and T12 fluorescent lamps with T8 lamps and electronic ballasts. As per the measurement and verification plan, it was proposed to follow International Performance Monitoring and Verification Protocol (IPMVP) Option A, which includes key parameter measurement. In the baseline period, kW was measured for the existing 400-watt metal halide and fluorescent lamps. The reporting period measurements consisted of measuring the kW of the new fixtures installed. The lamp burn hour was to be provided by plant personnel. The brewery did not have an energy management program; thus, measurement and verification of the savings was not considered an essential component in the project implementation. So we faced several hurdles during the verification of the energy savings, such as identification of electric circuits for retrofit fixtures.

The total kWh from the lighting retrofit project was verified to be 400,201 kWh. The demand reduction was verified to be 70 kW.

*Case Study 2*

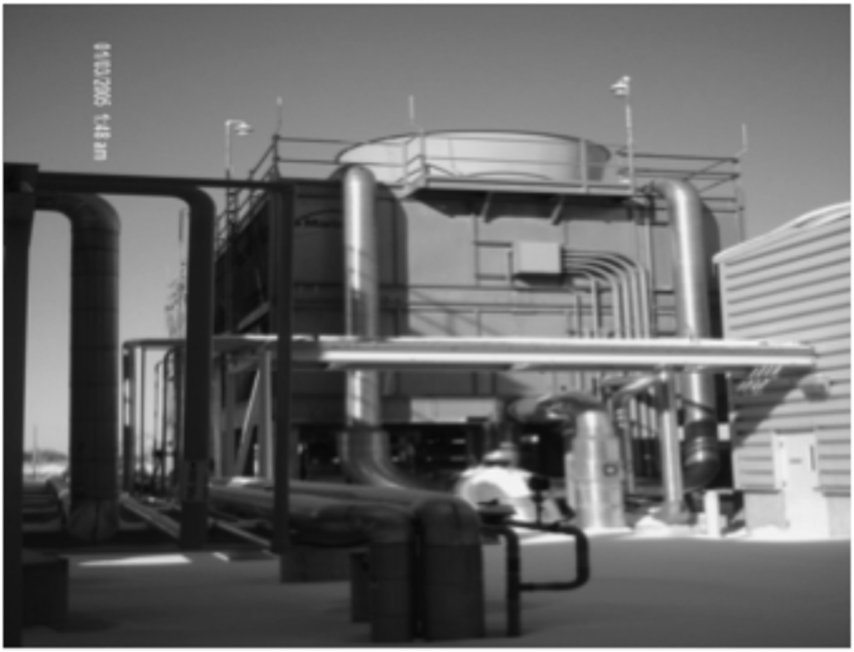
The case study consists of installing lighting controls, namely photocell and occupancy sensors in some of the lighting fixtures in the brewery. As a part of the M&V plan, kW and kWh were to be measured for the existing and retrofit fluorescent lamps for a day, both for the baseline and

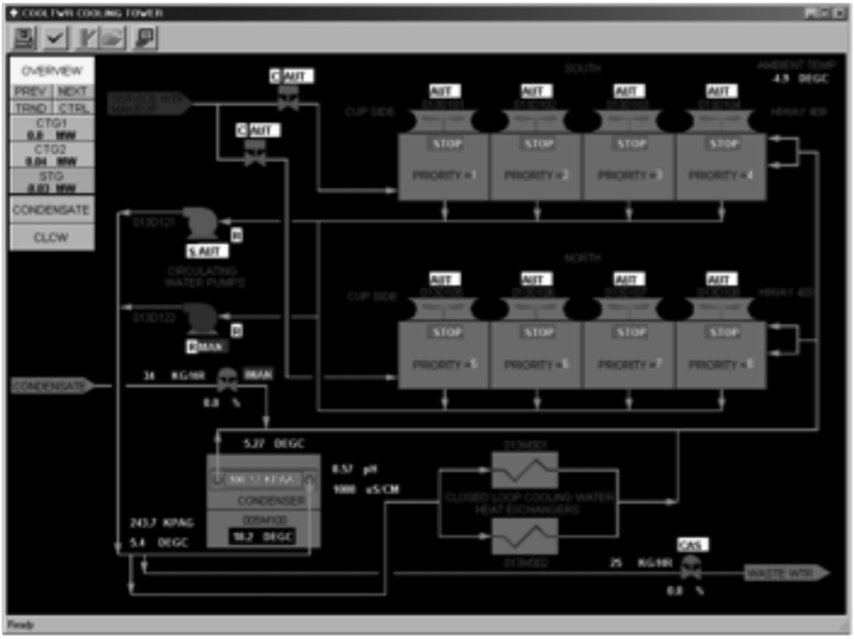
reporting period. As mentioned, the plant did not have an energy management program, and the tasks of identifying and locating the circuits for installing the data loggers (primarily in the reporting period) was a challenge, as the project manager did not consider the M&V process an important part of the project's implementation. The total kWh from the lighting control project was verified to be 38073 kWh.


*Case Study 3*

This case involves installation of a cooling water bypass pump in a cogeneration plant. The cooling water pump is a part of the plant and is driven by a 500-kW motor. The plant runs only about 18 hours a day, while the cooling water pump runs 24 hours. As a part of the energy conservation measure, the plant decided to shut down the large pump whenever the cogeneration plant was not running. It was decided that a smaller pump with a variable frequency drive would be installed to supply a minimum flow in the cooling water system to inhibit corrosion and biological growth.

Two projects were registered under the BOMA-CDM program. The first project was for the demand reduction, while the second project was for the energy reduction (kWh).

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The daily variation of Amps was noted from the Distributed Control System (DCS) to study the load pattern for the existing pump. Other parameters, like the position of the valve, were also noted. It was also mentioned by the operator that valve position was not generally changed. Based on the information collected from the site, it was proposed to follow IPMVP option A, which includes key parameter measurement. In the baseline period, kW was measured for the existing pump. The run hours were noted from the DCS system.

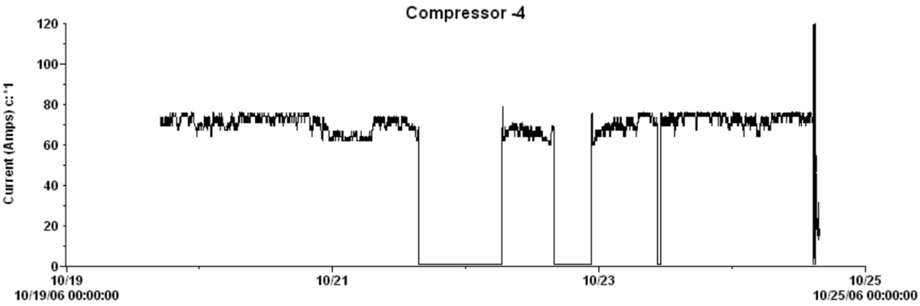
The reporting period measurements also consisted of measuring the kW of the newly installed pump, and the run hours were noted from the DCS system.

The cogeneration plant had an energy management program; therefore, there was good cooperation during the M&V review process of the pre- and post-project implementation phases Additionally, it had a data acquisition system that provided the critical information for the measurement and verification process. One of the other challenges was measurement of power of the high-voltage motor driving the pump. It was decided to take the motor reading from the DCS system. The total demand and electricity savings from the projects were verified to be 335 kW and 2297683 kWh, respectively.

*Case Study 4*

The case is taken from a coffee packaging facility. There are three air compressors in the plant. (Compressor 3 is a 75-HP lubricate screw compressor, compressor 4 is a 50-HP vane compressor, and compressor 5 is a 30-HP vane compressor.) Each screw compressor has its own refrigerated air dryer. The compressed air is collected in a receiver before it goes to the plant, and the compressed air supplied by the compressor banks is used for pneumatic controls of the packaging machines. Amperage data for all the operating air compressors (compressors 3, 4, and 5) were logged to determine the load profile. The energy retrofit project involved installation of compressed air sequencers. As per the M&V plan, it was proposed to log the amperage of all the compressors in the base case and determine the actual cubic feet per minute (ACFM) using Motor Master. In the reporting period, it was proposed to log the amps.

A regression model was created to correlate the number of machines being operated by the air compressors with the kWh. In the reporting period the compressors were operated with the sequencer, and the amperage of the compressors was logged to determine the kWh. The kWh of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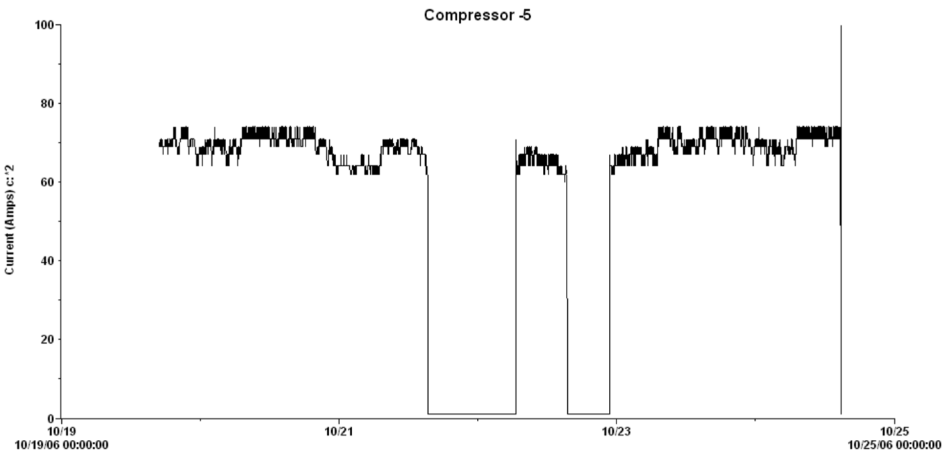
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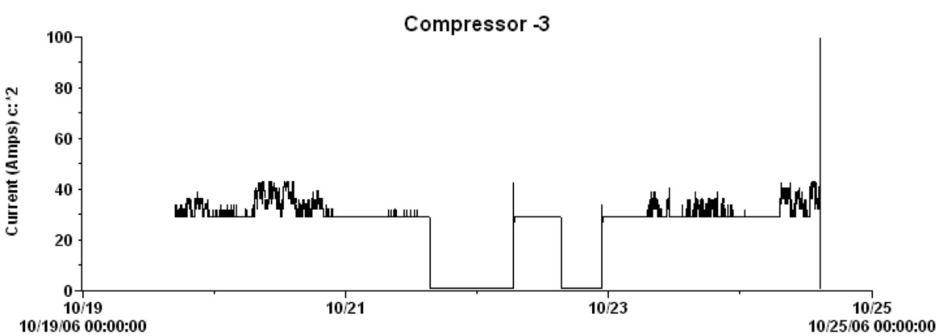
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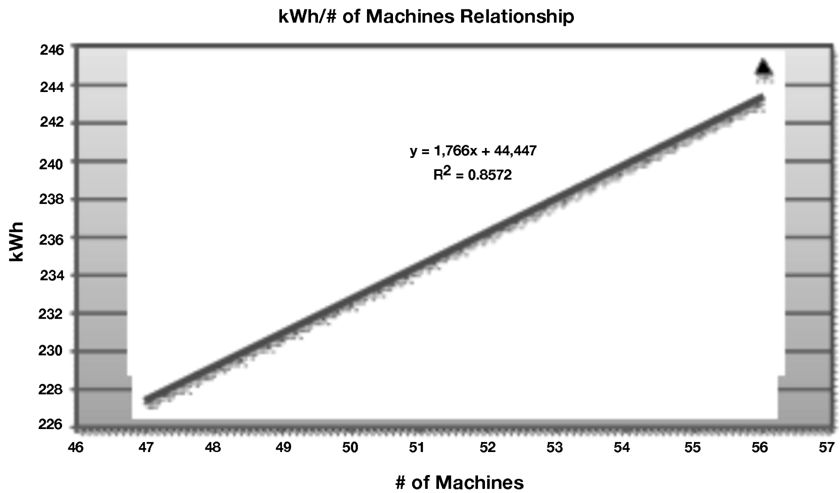
the baseline period was adjusted to the production level of the reporting period. Using the regression model to calculate the savings, the electricity and demand savings were verified to be 31260 kWh and 6 kW.




The coffee packaging facility had an industrial energy management program, and cooperation from the plant enabled such an exhaustive M&V process. The process also involved inter-departmental cooperation within the facility, yielding production data. The M&V process was very informative for the facility personnel, and all involved shared the success of implementing the compressed air sequencing project.

## CONCLUSION AND RECOMMENDATION

The M&V requirement for an incentive program can help in building capacity for all major stake holders of the energy retrofit project, including the consultant, the facility (energy manager), etc. The benefits of the M&V process in terms of capacity building and maximizing the incentive amount is highest for industrial facilities that have an energy management program. It is therefore recommended that programs which support energy efficiency/conservation projects should encourage implementation of a facility-wide energy management program.

One way to optimize cost is to consider a time-shared energy manager (TSEM). Small and midsized manufacturing companies lack the resources to maintain a full-time energy manager, so the energy management functions and responsibilities are left mostly to the plant manager. The plant manager, already loaded with numerous responsibilities, can hardly devote the necessary time and attention needed for the energy management function; in many cases, the manager lacks the skills needed to carry out such a function. At best, such a company hires an energy service company to identify and implement one or two energy reduction measures, an approach which does not lead to sustainable energy reduction for the plant. A qualified and experienced energy manager can offer energy management services to a number of small and midsized industries on an ongoing basis. Such services can be affordable to small and midsized energy consumers since the total service cost is shared between different companies.

**References**

Industrial Energy Management—Time Shared Energy Manager Program, Kaushik Bhattacharjee CEM, Proceedings WEEC 2010 Washington D.C.

Measurement and Verification Fundamentals and the International Performance Measurement and Verification Protocol (IPMVP)—AEE publication

Measurement and Verification Industry Practice and Principles—BOMA Toronto CDM Program

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ABOUT THE AUTHOR

**Kaushik Bhattacharjee, CEM**, Principal and co-founder of REIPOWER, an energy management firm based in Toronto, has over ten years of energy management experience. He has carried out several energy conservation projects and has guided the implementation of several energy optimization measures in various industrial environments such as plastics, pulp and paper, food processing, and metal tube manufacturing, as well as in commercial facilities such as offices, entertainment facilities, and movie theaters. He has also co-authored two books, contributed articles to a number of trade magazines, and made presentations in several IEEE international conferences, including the World Energy Engineering Congress on Energy Management. Kaushik was given the Energy Manager award for the Canadian region in 2010 by AEE for his outstanding accomplishments in promoting the practices, principles, and procedures of energy management. He holds a bachelor's degree in electrical engineering and is presently pursuing his masters degree with the New York institute of Technology, USA. He can be contacted at kbhatta@reipower.com or by phone at 289-468-1000.