

Investigation of Relationship between System Efficiency Curve & Measurement and Verification (M&V) of Energy Savings

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Subodh Chaudhari
West Virginia Univ.

Deepak Gupta
Southeast Missouri State University

Bhaskaran Gopalakrishnan
West Virginia Univ.

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ABSTRACT

This research attempts to investigate the effect of change in system curve on the energy intensity method of measurement and verification of energy savings. With recent push from US government on energy efficiency through EPACT 2007 and upturn in performance contracted energy efficiency project implementations the effective and accurate evaluation of energy savings as compared to the baseline is of paramount importance. The authors have studied different methods of Measurement and Verification (M&V) of energy savings from literature to compare and contrast and clearly bring out merits and de-merits of each. Finally, the role of production level variable plays in establishing the baseline energy usage is discussed. Though modern models proposed in the literature of determining baseline energy usage consider production level, this variable is compounded from two variables viz., time of usage of a system and fraction of total capacity usage. This study aims to find if a model considering these variables yields significantly different baseline energy usage than the traditional model.

INTRODUCTION

“You cannot manage what you do not measure.” This is very true with respect to energy efficiency projects because several factors affect the amount of savings that can be realized from these projects. One of the most important aspects for

implementing an energy efficiency project is to secure required funding for the implementation. With tough economic times, shrinking budgets, and risks associated with energy prices, it is very important to provide the confidence needed to secure funding for implementation. Measurement and Verification (M&V) is such a process that evaluates the potential savings with respect to the current energy consumption or the baseline. As per Efficiency Valuation Organization (EVO), “M&V is the process of using measurement to reliably determine actual savings created within an individual facility by an energy management program. Savings cannot be directly measured, since they represent the absence of energy use. Instead savings are determined by comparing measured use before and after implementation of a project, making appropriate adjustments for changes in conditions.” [6]

IMPORTANCE OF MEASUREMENT AND VERIFICATION

Under Superior Energy Performance Certification as rolled out by US DOE to achieve certification levels of silver, gold, and platinum, the participating facility must show energy intensity improvement of 5%, 10%, and 15% respectively over 3 years for energy intensive pathway [9]. The energy intensity improvement will be evaluated using the Measurement and Verification (M&V) protocol. The M&V process provides excellent feedback on energy efficiency

projects and therefore indirectly helps the organizations improve their operations and reap greater benefits from energy efficiency projects. It also helps them understand the project risks and prepares them to manage and allocate the risk outcomes to responsible parties. For example, in a project that is executed as a performance contract, some of the risk associated with varying operating hours and existing equipment may be allocated to the facility that is implementing the energy efficiency project while the others such as ones related to new equipment may be allocated to the energy service company (ESCO) guaranteeing the savings. M&V technique makes the accountability process transparent and helps managers discover and reduce the operation and maintenance problems that may result from poorly designed projects. The transparent nature of M&V process also leads to accurate estimation of emission reduction from the projects that may be used in emission reports. Some of the major energy efficiency improvement projects at automotive plants may require large investments and if the facility needs the assurance the investment will have an acceptable return on investment, an ESCO can execute the project under performance contracting.

PERFORMANCE CONTRACTING

Performance contracting is a service that provides a comprehensive set of energy efficiency, renewable energy, and distributed generation measures and may guarantee that the savings produced by the project will be sufficient to finance the full cost of the project [5]. In general, the performance contracting is delivered by an ESCO. The ESCO provides all the services related to components from design to implementation and M&V of the project. They design the efficiency measures, arrange long-term financing, and provide guarantee that savings provided by the project will justify the investment. Based on the information prepared for US EPA in 2007, most of the ESCO projects (OVER 70%) focus on energy efficiency. Performance contracting becomes more promising in facilities where investment options are limited and there is a need to reduce energy intensity. In the current economy, performance contracting becomes one of the very viable options for automotive industries in terms of implementing energy efficiency projects.

ENERGY MANAGEMENT STANDARD

The current ISO standards (ISO 9001 for quality management and ISO 14001 for environmental management systems) have helped organizations around the globe to institute continuous improvement programs and increase efficiency of their operations. ISO 50001 is proposed as energy management standard in this series and is expected to result into long term energy efficiency improvements. Recently, it was approved as draft international standard. It will provide the following benefits [7]:

- A framework for integrating energy efficiency into management practices

- Making better use of existing energy-consuming assets
- Benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in greenhouse gas (GHG) emissions
- Transparency and communication on the management of energy resources
- Energy management best practices and good energy management behaviors
- Evaluating and prioritizing the implementation of new energy-efficient technologies
- A framework for promoting energy efficiency throughout the supply chain
- Energy management improvements in the context of GHG emission reduction projects.

Superior Energy Performance is a certification program for industrial facilities. It is expected to be launched nationwide in 2011. The certification program is designed to help industries achieve continual improvement in energy efficiency while maintaining competitiveness and provide a transparent, globally accepted system for validating energy intensity performance improvement and management practices. One of the central elements of this program is the implementation of ISO 50001 with additional requirements to achieve and document energy intensity improvements which includes M&V [9].

REVIEW AND GENERAL COMPARISON OF M&V APPROACHES

IPMVP

The International Performance Measurement and Verification Protocol (IPMVP) provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects in commercial and industrial facilities. An indirect benefit is that it may also be used by facility operators to assess and improve facility performance. ECMs covered in this document include fuel saving measures, water efficiency measures, load shifting and energy reductions through installation or retrofit of equipment, and/or modification of operating procedures. The IPMVP protocol has become the national measurement and verification standard in the United States and many other countries and has been translated into 10 languages ¹. The current options include Retrofit Isolation: Key Parameter Measurement, Retrofit Isolation: All Parameter Measurement, Whole Facility, and Calibrated Simulation.

FEMP M&V

The Federal Energy Management Program (FEMP) M&V guidelines was created to provide guidelines and methods for measuring and verifying energy, water, and cost savings associated with federal energy savings performance contracts (ESPCs). This document is intended for federal energy managers, federal procurement officers, and contractors implementing performance contracts at federal facilities. The federal use of ESPCs was authorized in 1986. The FEMP M&V document has two primary purposes [1]:

It serves as a reference document for specifying M&V methods and procedures in delivery orders, requests for proposals (RFPs), and performance contracts.

It is a resource for those developing project-specific M&V plans for federal ESPC projects, especially under DOE's Super ESPC contract mechanism.

ASHRAE GUIDELINE 14-2002

The ASHRAE guideline 14-2002 (Measurement of Energy and Demand Savings) was developed to provide standard procedures for energy savings calculations. It is expected to provide a minimum acceptable level of performance in the measurement of energy and demand savings from energy management projects by comparing before and after energy use measurements (adjusted for non energy conservation measures changes). These measurements can serve as the basis for commercial transactions between an organization implementing energy conservation measures (ECM) and ESCOs or other energy conservation providers that rely on energy savings as the basis for repayment of the costs of the retrofit [4]. The basic measurement methods include the Whole Building Approach (prescriptive and performance), the Retrofit Isolation Approach, and the Whole Building Calibrated Simulation Approach.

STATE (NYSERDA, CALIFORNIA SPC) M&V

Several utility providers in the US offer incentives for verified energy savings and have required M&V protocols. Examples of such programs include California Utility Standard Performance Contract (SPC) Program, New York State Energy Research and Development Authority (NYSERDA), State of Texas Programs, etc. Under SPC, calculated savings projects do not require full measurement and verification. However, short-term and spot measurements such as that described in IPMVP Option A may be required [10]. With NYSERDA, the applicant must create an M&V plan in collaboration with NYSERDA's Technical

Consultant. Projects requiring M&V may be subject to partial withholding of the total incentive, which is payable after NYSERDA receives and approves the final M&V report ².

DISCUSSION OF PRODUCTION LEVEL VARIABLE IN BUILDING A MODEL FOR M&V

SYSTEM EFFICIENCY

System efficiency is a measure of how effectively supplied resource (fuel) is utilized to achieve useful work from a group of equipment that constitutes the system. For example, steam system efficiency will take into consideration the efficiencies of steam distribution, insulation, condensate recovery, in addition to boiler efficiency at particular load.

There are two types of energy systems in a plant based on the energy source as typically found in the United States for small to medium sized manufacturing facilities. These most common energy sources are electricity and natural gas. All the major energy systems found in these facilities operate on these two sources. The major energy systems found are: steam system, process heating system, compressed air system, pump system, fan/blower system, other process motors, and HVAC. The lighting system in manufacturing plant is usually not significant consumer of energy. The energy system (electrical/natural gas) efficiency will be combination of the efficiencies of individual systems that are served as illustrated in [Figure 1](#). The effective efficiency will be non-linear or linear combination of the individual system efficiencies. Moreover, it should be noted that the efficiency itself is not a linear function of partial load on the system. The individual system part load efficiencies are discussed below.

Steam System Efficiency

The variation in the boiler efficiency at part load is discussed elaborately in the literature. The major variation comes from the shell loss component of the boiler. The shell loss is only 1-2% at full load of boiler; however at the lower load shell loss can be 6-7% of the total energy consumption which decreases the efficiency of the boiler. Other reasons can include lack of proper control on the combustion air at part loads, increased insulation losses, and oversized piping system at lower load. [Figure 2](#), shows the boiler efficiency curve as obtained by calculator published by Natural Resources Canada - Office of Energy Efficiency [8].

Pumps/Fans/Motor Systems

At part loads, the losses in pumps, fans, or processing motors increase contributing to decreased efficiency. The part load

¹<http://www.evo-world.org/>

²http://www.nyserdera.org/programs/Existing_Facilities/electric.html