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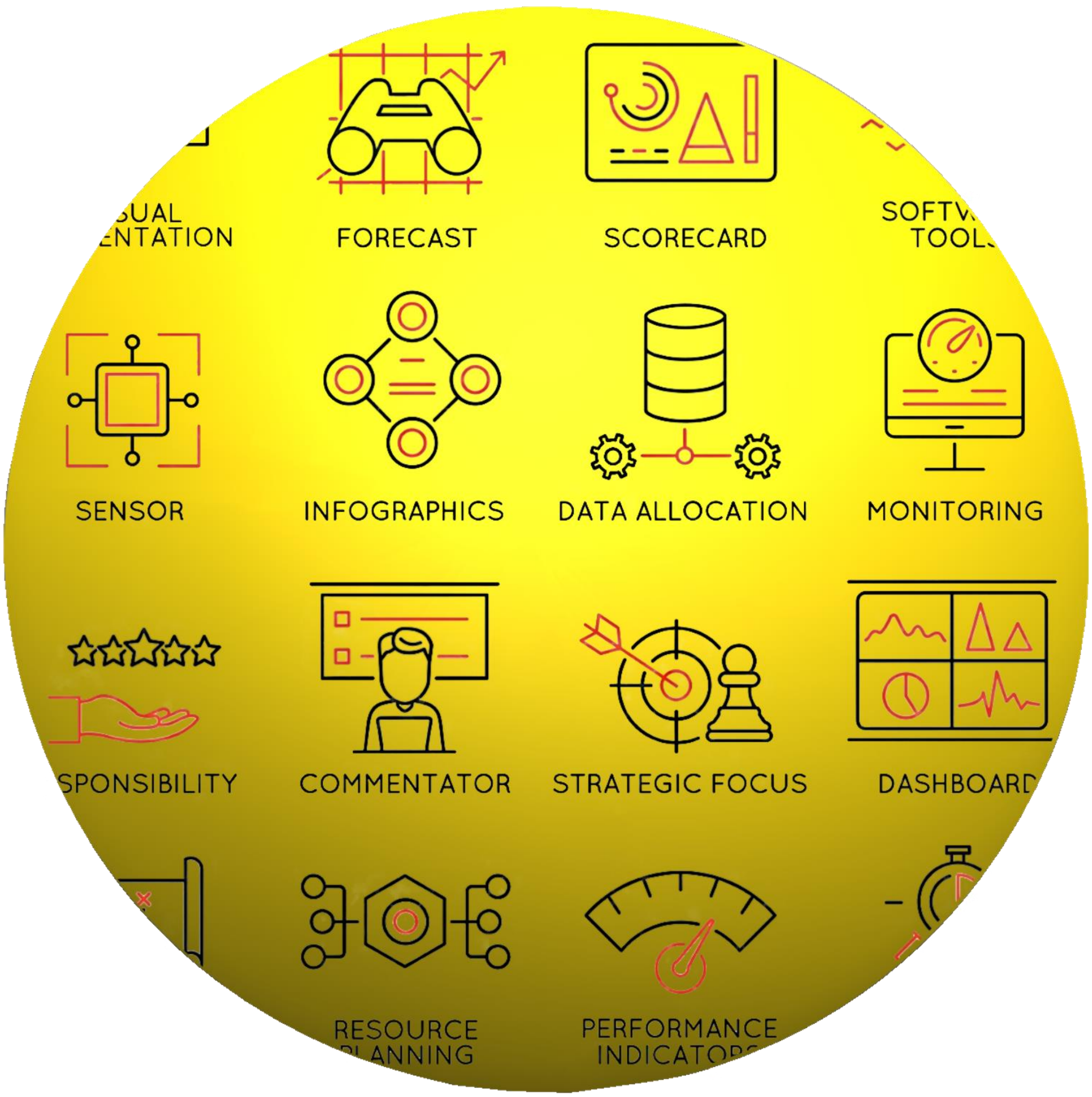
A GUIDEBOOK TO ADOPTION OF M&V 2.0



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Evaluation, measurement, and verification (EM&V) is a long-established practice using engineering calculations and statistical models to verify estimated energy savings, assess the performance of energy efficiency utility system resources, and help inform recommendations for future implementation activities.[1] Having a clear understanding of how a program will deliver results is critical to an effective EM&V process, and understanding how to best support the various components of the EM&V process is also vital to the success of a program.

While traditional measurement and verification (M&V) approaches continue to support demand side management programs, the rise of smart meters, smart devices, and innovations in energy data and analytics presents significant opportunities (and challenges) for this field of investigation. The shift towards using more meter-based approaches and advanced analytic tools to support M&V—often dubbed "M&V 2.0"—can credibly save significant time and resources for implementers and evaluators, and also help enhance customer engagement, increase accuracy of savings attributions, and support new innovative approaches for reaching and serving markets.

How do you capitalize on this paradigm shift, improve performance, and figure out whether the investments in energy efficiency achieved the objectives expected or required?

In this document, we examine current trends and present case studies that highlight the evolution and application of EM&V and showcase how the shift in M&V practices can, alongside the set of emerging technological trends, best support innovative program design and results. This guidebook also leverages critical insights and questions gathered through the regional engagement and input of more than 40 Midwestern stakeholders and key national experts. This activity was part of a Missouri Department of Economic Development, Division of Energy, and U.S Department of Energy (US DOE) grant-funded program that supported the successful development of Missouri's first state-wide Technical Reference Manual (TRM) and this document's exploration into and consideration of M&V 2.0.

[1] https://www.energy.gov/sites/prod/files/2014/05/f16/what_is_emv.pdf

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LIST OF ABBREVIATIONS AND ACRONYMS

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AMI	advanced metering infrastructure
AM&V	advanced measurement & verification
BEMS	building energy management system
Btu	British thermal unit
CDD	cooling degree days
CEI	continuous energy improvement
CO2e	carbon dioxide equivalent
DER	distributed energy resources
DI	direct install
DR	demand response
DSM	demand side management
EE	energy efficiency
EERE	[Office of] Energy Efficiency & Renewable Energy (US DOE)
EFLH	equivalent full-load hours
EM&V	evaluation, measurement, and verification
ESCO	energy service company
EUL	effective useful life
HDD	heating degree days
HPwES	Home Performance with ENERGY STAR
HVAC	heating, ventilating, and air-conditioning
IoT	Internet of Things
IPMVP	International Performance Measurement and Verification Protocol
kW	kilowatt
kWh	kilowatt-hour
LBNL	Lawrence Berkley National Laboratory
LED	light-emitting diode (efficient light bulb)
MMBtu	million British thermal units (Btu)
M&V	measurement and verification
M&V 2.0	measurement and verification 2.0
NEBs	non-energy benefits
NILM	non-intrusive load monitoring
O&M	operations and maintenance
P4P	pay for performance
RCT	randomized control trial
RMI	Rocky Mountain Institute
RTEM	real-time energy management [system dashboard]
RTU	roof-top unit (unitary HVAC system)
SEM	strategic energy management
TRM	technical reference manual
UMP	Uniform Methods Project

EXECUTIVE SUMMARY

The advent of "big data" in the utility landscape and the generation of hundreds of terabytes of data per year from energy meters and connected devices in buildings is driving the transformation of the traditional utility model. These new data streams are requiring utilities to think beyond their top-down relationship between the grid and individual customer meters, to a new two-way integrated network between the grid and individual customer devices.

The opportunity and ability for industry to harness emerging tools and devices (big data analytics) is also pivotal to helping utilities stay relevant, as data that can be translated into real-time actionable insights can inform better operational decisions, customer-centric offerings, and more cost-effective program implementation.

Equally, for planning professionals and evaluators alike, the value afforded by conducting M&V through a semi/automation process can help to reduce the cost of data collection and analysis (increasing the cost-effectiveness of the process); improve the timeliness and value of savings analysis; identify potential risks early on, allowing for any necessary mid-program adjustments; and encourage a more proactive dialogue with implementers, regulators, and other stakeholders.

The objective of this guidebook is to focus attention on how this current trend, most commonly framed by the term M&V 2.0, can assist with program optimization by providing actionable insights for program designers, implementers, administrators, regulators, and others about the challenges and opportunities related to the smart grid infrastructure, remote load monitoring, embedded sensors, etc. This guidebook serves to provide each of these parties with not only a better understanding of M&V 2.0, but also information and recommendations on how to adopt M&V 2.0 practices alongside the set of emerging technological advancements to best support innovative program design and results. It should not be considered an exhaustive resource nor comprehensive listing of all possible approaches, as the prime goal of this work is to encourage the support and framing of regional discussions on the impact of innovative technologies and enhanced data availability at the state and national level as a means to strengthening efficiency programs in the future.

A GUIDE TO THE GUIDE: HOW TO USE THIS DOCUMENT

Designed to be read like a guidebook, this document takes a familiar approach to engaging the reader, asking a series of questions throughout each section that are aimed at helping *you* better understand how to navigate the complexities of M&V 2.0. The information and recommendations can also be used to help better determine what approach and opportunity would best support your experience or interaction with efficiency programs in your jurisdiction, whether it be streamlining savings estimations, increasing market access, improving performance metrics, lowering the cost of program evaluation, or something else.

The intended audience is representative of the original stakeholder group that participated in a six-month collaboration effort that concluded in early 2018 with a hands-on interactive presentation and M&V 2.0 exercise at the 2018 Midwest Energy Solutions Conference in Chicago, Illinois.[2] This group included state utility regulators, administrators of energy efficiency programs (including publicly owned and investor-owned utilities as well as government and non-governmental organizations), efficiency program implementers, evaluation consultants, and other stakeholders, including industry representatives, technology providers, and consumer advocates.

While this guidebook intends to provide each of these users with a better understanding of M&V 2.0, it should not be considered an exhaustive resource nor comprehensive listing of all possible approaches. The goal of this work is to compliment broader efforts led by the US DOE's State and Local Energy Efficiency Action Network's EM&V Working Group. We also aim to encourage the support and framing of regional discussions on the impact of innovative technologies and enhanced data availability for EM&V efforts at the state and national level and to strengthen efficiency programs in the future. We also acknowledge that, in order to remain relevant and useful, it will require continuous update to keep pace with changes in this field and innovations across technologies, energy data, and analytics.

This guidebook assumes the reader has a basic understanding of current EM&V practices for energy efficiency programs. This table provides a summary of the guidebook contents and their usefulness to different readers.

Section	Intended Audience	Contents
Executive Summary	Readers interested in a brief introduction to M&V 2.0 and what this Guidebook will present	High level overview of guidebook purpose, and content, and how to navigate and use the Guidebook
A Guide to the Guide	Readers interested in understanding the structure of this document and how best to use the content, tools, and "homework" questions	Navigational information regarding the content and structure of each section, and interactive engagement tools
Background; M&V 2.0 Methods and Data Sources	Readers who want an overview of what M&V 2.0 is, and require background on current EM&V practices and how 2.0 methodologies compare to traditional methods	Definitions, descriptions, and key issues associated with types of evaluations related to M&V 2.0, and comparisons to traditional methods, specific standards, and resources

[2] A copy of this exercise is presented in this guidebook as Appendix 2.

Section	Intended Audience	Contents
Choosing a Destination: What Problem Are You Solving?	Readers who are interested in determining how M&V 2.0 might apply to resolving their program, sector, or other target issues	Descriptions of program/sector and questions that encourage reader to determine what they want to focus on (metric, accuracy, participation, transformation, data, access, savings)
Surveying the Landscape: Examples of New Program Models	Readers interested in understanding how M&V 2.0 can be practically applied to existing and new programs	A non-exhaustive list of existing programs that use M&V 2.0
Charting a Course: Selecting an Efficient Technology/ Measure	Readers interested in learning more about specific technologies and their application in a program/market	Overview of how M&V 2.0 can affect different measure offerings independent of any new technology as well as alongside it
Stretching Your Legs: Trying a Pilot	Readers interested in understanding what goes into making a great pilot, from planning to engagement	Recommendations and step-by-step Information on how to best move beyond an M&V 2.0 vision to implementing a successful pilot
Rules of the Road – Regulatory Considerations	Readers interested in understanding how to navigate M&V 2.0 within the current regulatory landscape	High-level overview of how to approach the fundamental regulatory barriers to deployment of M&V 2.0
Resources	Readers interested in more sources of M&V 2.0 information as cited in the guide	List of additional M&V 2.0 resources, with hyper-links to key documents or group activities
Appendix 1: *Tools and Questionnaires*	Readers interested in asking probing questions about M&V 2.0	List of workbook questions presented to project stakeholders
Appendix 2: *M&V 2.0 Group Activity*	Readers who are interested in facilitating a group M&V 2.0 exercise with their peers	Summary workshop information used to guide an interactive stakeholder group exercise and conversation on M&V 2.0

Now that we have piqued your interest, what next? There are numerous articles, studies, and reports predicting the varied benefits of M&V 2.0 and comparing various technologies, even pilots with third-party evaluations and this document similarly provides a detailed resource section at the end listing these literary sources for you to read and dig deeper into what M&V 2.0 is. But how do you determine if M&V 2.0 could be used to solve problems for you in energy efficiency and demand response programs? This guidebook is set up to help you figure that out. Recognizing that there is no one right approach, it charts a course for you through some of the latest techniques and technologies informing advanced M&V approaches by helping you to:

1. determine your goal or starting point – framed by the introduction within each section;
2. assess your resources, review your options, and identify potential selection criteria for next steps through the main content of each section; and
3. think through next steps with some theoretical M&V 2.0 practice questions and check-lists to use in each section's closing "trip planner."

You can read this guide start to finish for general knowledge. Or you can use it to help plan an actual project, responding to the trip planner questions and manifests as you work your way through the guidebook. You can even jump around like a true reference manual, using the summary guidebook table above to find relevant information.

To get the most out of this document, let's set your sights on a promising destination, and plan your journey so you can embark with confidence! A good starting point may be framing the trip planner questions below with an overarching awareness of what you are trying to measure and acknowledgement of whether you are interested in the achieved or potential impact of this measure. Energy, demand savings, fuel, water, CO2e, customer satisfaction, trade ally goals, and market transformation are all common metrics that are frequently tracked by utility programs, so get your thinking cap on and let's get started!

TRIP PLANNER QUESTIONS

1. *What is your motivation for exploring M&V 2.0?*
    a. *Improving M&V outcomes?*
    b. *Improving program performance?*
    c. *Developing new program models?*
    d. *Supporting existing measure or new technologies?*
    e. *Responding to customer requests and needs?*
    f. *Interested in learning more about the latest trends and pilot examples?*
2. *What impact are you trying to measure? Efficiency savings or demand response?*
3. *Are you measuring potential or achieved savings?*
4. *What is the current deficiency with the previously-available M&V techniques?*
5. *What is the threshold for success (level of accuracy, feedback time lag, etc.) needed to support the desired application?*
6. *Do you need or want to deliver specific (mass-customized) project-level savings estimates, or can you use program-level aggregated results?*

BACKGROUND: A LAY OF THE LAND

Before embarking on an exploration of M&V 2.0, it may be helpful to gain some familiarity with the current landscape. Measurement and verification, or "M&V," is a long-established practice using engineering calculations and statistical models that apply data from utility meters, sub-meters, surveys, and equipment ratings collected from field studies. These techniques were developed to estimate the energy or demand savings performance and cost-effectiveness of energy efficiency activities to appropriate levels of certainty, which in turn can help to support the more-effective planning of future programs or projects. Often, a single estimate of the average savings from each unit of a given type of efficiency upgrade (appliance installed, home weatherized, etc.) will be claimed as the "deemed" savings for each unit that is installed or incented by the program. For larger or more variable efficiency upgrades, the savings may be calculated on a "custom" basis, which sometimes includes the use of meter data (either from the utility meter or a sub-meter installed on the upgraded equipment) from the specific project. State regulators, public and private energy efficiency portfolio administrators, program implementers and evaluators, financial institutions, and other market actors all look to M&V of program activities for various reasons, legislated or otherwise.

A primary benefit of M&V is that it helps to identify which energy efficiency measures and/or programs have met their objectives, which ones are cost effective, and what changes could help the programs be more successful. A properly designed M&V plan can also provide program implementers with the ability to adjust the direction of a program or product as issues develop and, from a financial perspective, produce verifiable results that can be used to identify which measures have the biggest return on investment, realized energy savings, and therefore cost effectiveness. M&V can also highlight implementation opportunities and ways to improve efficiency program planning and efficacy. Equally, an effective M&V process can identify (and sometimes quantify) non-energy benefits (NEBs) such as economic impact, air quality improvements, water consumption, green-house gas emission reductions or other environmental attributes, as well as demand or supply-side factors.[3]

So how have the practice and current M&V activities changed so drastically to be widely considered to be entering a new, "2.0", era?

How Others Define M&V 2.0

Given that the definition of M&V 2.0 varies depending on the referenced source, one could be forgiven for assuming that it is simply a catch-all marketing term. While there is no single definition of M&V 2.0 the following provided by the Rocky Mountain Institute represents a comprehensive description.

M&V 2.0 refers to the increasing granularity of available energy consumption data, and the enabling of automated M&V methods that continuously analyze the data and provide early, accurate and valuable insights to various stakeholders about energy savings estimates.

DEFINING M&V 2.0

The branding of (purportedly) revolutionary technologies with "2.0" began with the moniker "Web 2.0," popularized in 2004 in reference to a wave of user-generated content transforming the internet. No one technology drove this change, nor did static corporate marketing web sites disappear, but the impact was nonetheless rapid and far-reaching. In a similar fashion, the term M&V 2.0 is used to describe new analysis tools

[3] https://www.energy.gov/sites/prod/files/2014/05/f15/benefits_emv.pdf

and techniques that are coming into use to help manage and make sense of the exponential growth in user-generated energy consumption data stemming from advanced metering infrastructure (AMI), smart devices, building management systems and other points of collection, such as:

- Access to low-cost, high-frequency data from smart meters and connected devices that can provide near real-time savings estimates.
- Ubiquitous networks such as existing Wi-Fi in buildings, low-cost/low-bandwidth cellular service, and a parade of communication protocols such as ZigBee, Bluetooth Low Energy, and LoRa, which are optimized for embedded building monitoring and control applications.
- Powerful data analytics tools, including rapidly evolving machine learning techniques increasingly able to detect complex patterns and make accurate predictions about future behavior and savings that can help improve the management, design, and implementation of efficiency programs.

One of the great promises of M&V 2.0 is that it will bring a higher level of transparency, accuracy, and reliability to efficiency programs' savings estimates. And that this in turn may also help to modernize energy efficiency markets, create innovative delivery mechanisms, and revise policies and standardize approaches to tracking not only energy savings but also the various NEBs that stem from these programs. More specifically, though, the hope is that alongside traditional M&V techniques, these new M&V 2.0 tools and approaches will help to harness the proliferation of information animating from these technologies and the Internet of Things (IoT) in a meaningful way that creates true value beyond incremental improvements for program designers, implementers, evaluators, and society alike.

For example, as this guidebook will illustrate, M&V 2.0 has the ability to enable market-based pay-for-performance or procurement type delivery models (as currently offered by ESCOs) for efficiency programs. It can support approaches to behavioral-based energy savings. It may also leverage "learning" devices such as thermostats that program themselves. And it could use weather-normalized baselines to estimate how much energy a building would have used if efficiency upgrades were not performed and much more by capturing:

1. Savings calculation results driven by actual data from participating customers' utility meters, connected devices, etc. In many cases, such as with Pay for Performance programs, this may result in customer-specific savings estimates.
2. Measure-savings results calculated in "real-time" (although results may be reported no more frequently than monthly) and updated over the entire performance period of the measure's effective useful life (EUL).
3. Automated calculations that require minimal intervention from practitioners, shifting the focus of M&V staff from performing savings calculations to applying automated tools, interpreting the results, and exploring the data to find the underlying causal relationships that could yield insights about how to improve outcomes.

In short, while the branding of M&V 2.0 may imply a goal of replacing current M&V tools and techniques with new ones, this is more a reflection of their origin than their future. Just as Technical Reference Manuals (TRMs) supported the growth of publicly funded mass-market utility efficiency programs by transparently calculating savings values, the value of M&V 2.0 will not only be in leveraging more value out of evaluation budgets but also adding precision to annual savings reports and providing feedback on ways to increase gross savings, and perhaps even improve realization (ex-ante) rates. Moreover, as noted above and to be illustrated below, these technologies have the potential to enable new methods of engaging customers, financing projects, and improving the efficiency of our built environment. However, these new tools also have their limitations; in most cases they are only capable of measuring directly-observable “gross” savings, and must still be adjusted for free-ridership, line losses, and other factors that contribute to the “net” savings goals that many programs must achieve.

M&V 2.0 METHODS AND DATA SOURCES TO IMPROVE CALCULATION OF SAVINGS FOR INDIVIDUAL CUSTOMERS: WHAT ARE YOU TRYING TO MEASURE?

While "M&V 2.0" is becoming a marketing buzzword that is applied to anything using data or advanced analytics to identify or estimate savings, we propose using a narrower definition: a method of calculating savings that supports new types of services and business models by increasing the granularity of measurements in time (e.g., peak-coincident impacts) or location (e.g., customer-level savings estimates). Ideally, these improvements are also achieved through automated calculation techniques so those measurements can play a more active role in the success of the program. Other terms that are often used somewhat interchangeably include "Advanced M&V" and "Automated M&V" (abbreviated AM&V).[4] While the benefits of M&V 2.0 may include more accurate or continuously updated results, those improvements must be considered holistically; not simply considering overall portfolio precision, but noting if it enables a new measure category or program design that previously could not be calculated cost-effectively using engineering models and assumptions. This means not simply comparing year-over-year M&V budgets, but factoring in how targeting and real-time tracking allows the program to use marketing and incentive dollars to bring in more savings. The cost for collecting and analyzing data may also shift to program budgets if the tools are used for monitoring and optimizing programs, which further complicates the hunt for M&V savings.

A program's M&V strategy can encompass savings estimates and calculations throughout the life cycle of a project. This includes estimating savings for proposed measures, verifying savings of installed measures, and evaluating the realized impact of a program. Estimating deemed savings from energy conservation measures with traditional M&V techniques is typically only able to customize savings estimates based on factors such as the type of building, the size of the equipment, and other easily identifiable factors. These savings values are based on data and analysis, but even with more sophisticated forms of data and more advanced analytics, such market studies or prescriptive savings calculations do not actually constitute M&V 2.0 techniques. Many M&V practitioners will also point out that billing analysis, sub-metering, and other techniques listed in this guide are already used for program evaluation. Again, these do not cross the threshold of M&V 2.0 unless they are done in service of dynamic savings estimates that are customized based on automated data analytics for each potential customer. An example of such a dynamic savings estimate could be a home weatherization program using a dashboard that calculates savings for each participating home in real-time based on a measured change between pre- and post-project energy use.

The step-change to version 2.0 happens when you can find data sources and analytical techniques that can be applied to every participant in the program to customize savings calculations and track them through time. This approach may begin with the original savings estimate that the program and participant use to screen the measure to decide if it is a good investment. It may also continue through the post-installation period so that a third-party evaluator can multiply those same calculated changes in energy use by a net-to-gross factor (based on attribution of those projects to the program's intervention) in order to determine overall program impact. But this application to every project explains why integrated data collection (whether through utility meters, connected devices, or other sources) and automated analyses are required to make this approach cost-effective. Note that this mass-customized savings approach can still be flexible; it is possible to fall back to default values in these calculations

[4] For example, see LBNL's research in this space: http://eis.lbl.gov/auto-mv.html

to accommodate participants who decline to supply data for privacy reasons, or whose data has been lost due to a glitch, for example.

WHAT ARE YOU TRYING TO MEASURE?

While the main focus for efficiency program M&V is typically energy and closely related metrics, there are typically a range of other metrics that either may be directly relevant to the performance of the program or at least tracked and managed. Some M&V 2.0 techniques can help measure things other than energy savings, particularly when moving beyond billing data analysis to use survey data, web traffic trends, or market participation data. The underlying concept is the same: find one or more consistently available data source that can be causally linked to the metric in question, using analytical techniques that combine relevant data sources and help to make the relevant "signal" more clearly detectable. Here are a few example metrics that are frequently tracked by utility programs:

1. Energy savings
2. Demand savings
3. Fuel savings
4. Water savings
5. CO_2 savings
6. Customer satisfaction
7. Trade ally goals – effective promotion of program
8. Market transformation
9. Program uplift

HOW DO M&V 2.0 TECHNIQUES AND TECHNOLOGIES RELATE TO TRADITIONAL PROTOCOLS SUCH AS THE IPMVP OPTIONS?

While the data sources and analysis techniques used by M&V 2.0 may be different than those used by traditional M&V, the goals are often the same. M&V practitioners have developed a set of protocols for ensuring that the measurement is appropriately using the available data to quantify the change in energy use. The industry-standard reference guide is the *International Performance Measurement and Verification Protocol* (IPMVP).[5] The IPMVP describes many aspects of the M&V process, but some of the most often-referenced parts of the protocol are the four options for calculating energy savings. In this section, we explore how new sources of data and analysis techniques could be used in the context of these four options.

OPTION (A) RETROFIT ISOLATION: KEY PARAMETER MEASUREMENT

Option A includes a mix of direct measurement and engineering assumptions. Where it is determined that variability would drive errors in savings estimates, parameters are directly measured. Other parameters are estimated based on engineering assumptions or data deemed to be reasonably reliable (e.g., averages from past field studies, manufacturer's performance data, etc.). Take a lighting retrofit for example: you might deem the wattage difference between the new and existing lighting fixtures based on manufacturer's specifications and directly meter the facility's lighting usage to determine a schedule and annual run hours. In this case, the key

[5] IPMVP is published by EVO, the Efficiency Valuation Organization: https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

parameter would be lighting hours of use determined through direct measurement. It is possible that advanced methods could supplement and scale this approach to more easily derive key parameters (such as annual run hours calculated from AMI data versus direct metering as in this example) to achieve customer-specific and real-time estimates of savings.

OPTION (B) RETROFIT ISOLATION: ALL PARAMETER MEASUREMENT

This option is similar to Option A but requires that all relevant parameters be directly measured, traditionally making this one of the more challenging and expensive options. For example, those efficiency upgrades with larger variability in operation and interaction with other building systems (e.g., commercial HVAC or industrial process equipment) may require direct metering of all energy consumption and operating conditions to accurately estimate savings. After measuring a representative period both before and after the efficiency upgrade, the change in energy use can be estimated and normalized using all key parameter measurements.

Built-in monitoring and communications circuits in appliances and even larger C&I equipment are becoming more common, so this approach could become much easier to apply in those applications. Non-Intrusive Load Monitoring (NILM) is another way to get low-cost, device-level data by disaggregating individual loads from whole-building data. The accuracy of such techniques is the subject of ongoing field trials, but in the context of M&V, the alternative should always be considered: what is the accuracy of assuming that every participant has identical baseline equipment size, efficiency, and run hours? For large C&I projects savings are typically estimated using customer-specific run-time inputs, but that approach is only feasible where a site-specific engineering analysis is cost-effective. What if a similar level of customization could be achieved with automated methods?

OPTION (C) WHOLE FACILITY

This “whole-facility” approach has been the focus of much of the recent work on M&V 2.0 tools and program designs. This is in part because the utility meter data used for this kind of analysis are easily available to many efficiency programs, not only for participants but also for comparison groups. When such control/treatment approaches are used, the savings calculations are often built on this whole-facility approach by adding a difference-in-differences or regression model adjustment to measure any changes in energy use that are not attributable to the program intervention. This calculation technique measures the change in energy use for both the participant group and for a comparison or “control” group that did not get the intervention, then subtracts the naturally-occurring difference from the program-induced difference to isolate the impact of the program.[6] Because these calculations can be done using only utility meter and weather data, it is possible for utility programs to use them for targeted and customized mass-marketing or for real-time program dashboards.

At the individual building level, regression models are used to either estimate the “counter-factual”, or baseline energy use had the efficient measure(s) not been installed. Alternately, both pre- and post-installation use patterns can be normalized to a typical meteorological year before subtracting one from the other. The most common models are partwise linear regressions against outdoor dry-bulb or degree-day data, such as those provided by ASHRAE’s inverse modeling toolkit. Other models are starting to emerge that either factor in a broader

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[6] For more on randomized control trial (RCT) and other M&V techniques, see the Energy Efficiency Program Impact Evaluation Guide https://www4.eere.energy.gov/seeaction/system/files/documents/emv_ee_program_impact_guide_0.pdf

set of weather inputs such as wet-bulb temperature or use schedule data if the energy data is available at intervals better than daily, as is available from AMI meters. Some of these advanced models are available only through commercial packages, but others are offered as open-source software so that the analysis code can be inspected and even improved if desired. Examples of the latter include OpenEE Meter and the LBNL time-of-week and temperature model.[7]

Production and other sub-metering data can be added to the model to make a more robust fit, as is often used by Strategic Energy Management (SEM) programs, and are incorporated in some commercial Real Time Energy Management System (RTEM) dashboards. Obviously, the addition of data beyond the utility meter makes these projects more expensive, and typically relegates them to the large C&I portfolio only. However, it is possible that low-cost energy tracking dashboards will be able to incorporate other data sources as standard protocols mature or integration services emerge. The capability for services like those dashboards to leverage the embedded measurement, control, and networking functionality in millions of devices is often billed as the "Internet of Things" (IoT). Due to rapid advances in the software and hardware technologies that these tools are built on, as well as growing demand from building managers and energy service providers, the landscape of services for monitoring and managing building energy use is changing frequently. Fortunately, there are some research efforts to track and evaluate these tools and services.[8]

Uncertainty analysis is needed to evaluate the meaning of results. Regression analysis will always produce a model that can be used to calculate impacts, but if the energy use was not consistent or predictable given known factors such as weather, that model will have a wide error band. When the energy use predicted by the model includes an uncertainty of plus-or-minus 10% and the expected project savings is only 5%, the "savings" calculated from that model will not be reliable. This is because sources of unexplained variation such as occupancy, production/sales, or other behavioral factors could make it look as though the efficiency intervention was over- or under-performing, while in fact the actual impact of that measure would not be clearly visible through the "noise" of those other factors. Solutions to this problem in the C&I sector include selecting projects with larger expected savings, selecting customers with more consistent usage, increasing meter data intervals to capture daily or hourly energy use, and using more advanced models. In the residential sector, or in cases where it is not necessary to true-up results with individual customers, then the savings across a portfolio of customers can be aggregated to reduce uncertainty.

OPTION (D) CALIBRATED SIMULATION

Building modeling is another way to both estimate savings potential and to simulate baseline consumption once a project is complete. Creating these models has traditionally required significant time investment by modeling experts. New tools such as OpenStudio (which is built on an existing simulation platform, EnergyPlus) allow automation of model development to the point where it is possible to simulate measures by implementing a base model that matches the building's performance and then testing the performance gains achieved through various improvements, including interaction effects. Some modeling tools like OpenStudio are able to build a virtual model

[7] See Mathieu et al., Quantifying Changes in Building Electric Load, With Application to Demand Response. IEEE Transactions on Smart Grid 2:507-518, 2011

[8] See Granderson, J, Fernandes S. 2017. State of Advanced Measurement and Verification Technology and Industry Application. The Electricity Journal 30:8-16. DOI: 10.1016/j.tej.2017.08.005

without requiring explicit input of all the geometry, assemblies, equipment, and sequences. They need only a small subset of the most salient details and then infer the rest, automatically calibrating those results against meter data. They then recommend measure packages based on a multitude of simulations done to test the performance of each combination.

CHOOSING A DESTINATION: WHAT PROBLEM ARE YOU SOLVING?

The future for efficiency programs using M&V 2.0 has the potential to be dramatically different from the current paradigm. As we have already implied, M&V 2.0 is not just about determining energy savings, it is a way to better align program stakeholders, customers, and market partners around a shared goal of demonstrably achieving energy savings. So, as a starting point on your journey to better understand and assess adoption of M&V 2.0 practices, it is helpful to know what objective you are trying to reach, challenge you are trying to best approach, or problem you are trying to solve.

For illustration purposes, this section and the table below focus on identifying opportunities and challenges within each segment of a tradition Demand-Side Management (DSM) program's markets: residential, commercial, and industrial. These might be driven by new or existing program goals, the availability of new data sources or tools, or simply the timing of program design cycles. The market segments should be already identified based on traditional techniques, such as filtering by rate code or demographic data that already exists in the customer database that might flag an account as "small business" or "rental home."

You may be intimately familiar with some of the examples listed below, but in reviewing this list we encourage you to identify other key characteristics that could be applied to each box, or add a new market segment that is important to you (e.g., Agriculture, Institutional, etc.). The purpose of this exercise is to help you identify and think through how to *reach* and *serve* hard-to-reach groups within each market segment, such as rural residential customers, low-income and tenant groups, or small and mid-sized businesses. It also lays out a few quick suggestions on how to engage these groups using M&V 2.0 approaches and other innovative analytic tools and technologies. Later in this guidebook we will help you think through how to best select a vendor or technology to support your chosen M&V 2.0 approach and ensure that it is providing the services and functionality needed. For now, focus your attention on a market segment, and document the drivers and constraints associated with that segment for you. While some M&V 2.0 solutions can be applied to multiple programs and markets, the strengths and weaknesses of many solutions will make them better suited to a subset of your program.

Table 1: Common DSM Market Segment Characteristics

	Residential	***Commercial***	***Industrial***
Opportunities	Homogeneous building characteristics Growing "smart home" appliance ecosystem	Larger energy use means more potential for savings driven by fewer decision-makers, better case for investing in sophisticated data tools and services.	Intelligent Efficiency can improve productivity as well as decreasing energy intensity[9]
Challenges	Small savings opportunities per home Residents have little time to engage with	More complex, varied building and energy uses. Some variation in energy use driven by	Large variations in use driven by production fluctuation. Many custom-building

[9] See ACEEE's reports on the topic: https://aceee.org/topics/intelligent-efficiency

	Residential	Commercial	Industrial
	utility, little knowledge of (and perhaps interest in) utility programs	occupancy or business-demand fluctuation.	systems for controls and data collection.
Data	Utility bills, AMI, connected home, IoT	Utility bills, AMI, sub metering, Building Energy Management System (BEMS)	Utility bills, AMI, sub metering, BEMS, production levels
Sample Programs	Behavior programs, such as home energy reports	Remote audits, retro-commissioning, Pay-for-Performance (P4P)	Strategic Energy Management (SEM)
Channels	Mass-marketing – targeted mailers or bill inserts, Web portal (bill payment, etc.), Weatherization contractors / direct install program, Phone app	Mass-marketing – targeted mailers or bill inserts, Web portal (bill payment, etc.), Account managers or technical staff who make site visits	Web portal (bill payment, etc.), Performance dashboard with utility and sub-meter data in context with baseline and/or goals, Account managers or technical staff who make site visits

For more examples of energy-saving technologies suitable for each market, see the table in the section "Charting a Course."

As became apparent during our own investigations with interested stakeholders across the Midwest in answering this first question, it is important to recognize this exercise is not focused on how to use M&V 2.0 to identify or segment your customers but rather to focus your initial exploration of M&V 2.0 around the needs of the markets already identified, using raw materials and data you already have.

Another problem that became apparent within the group of stakeholders is that identifying the right problem to solve will require multiple perspectives. Program managers do not want to redesign M&V procedures when designing new market initiatives to better serve customer needs and meet savings goals. M&V staff do not usually have the luxury to change the way customer data is collected, how incentives are set, or how relationships with communicating devices are established. While there may be new models for delivering energy services and measuring the impact, if they require changes to multiple portions of the program lifecycle (design, delivery, measurement), then implementation will require the coordination of representatives from all those areas.

Equally, many found it hard to separate the discussion of how M&V 2.0 tools can be used to support programs by providing more timely and granular savings estimates from traditional evaluation practices that calculate savings attribution. Stakeholders expressed concern about changing or challenging "*what is* currently working" or proposing trials of "what they would like to *try out*" for fear of evaluation retaliation.

Based on the additional input this project received from other regional and national experts in the field, this problem is not unique. So, as you work through the guidebook and review the trip planner questions below, consider reaching out across your organization or department; engage your IT and billing department, and look forward to increasing a collective self-awareness of the challenges and aspirations you face. Engaging representatives from across multiple different divisions/groups as well as within individual groups can help you effectively think through the integration of M&V 2.0. You may also discover aspects of a program that were unpredictable, agree on current processes that participants find burdensome, and find agreement on what products or services are of most interest but that you do not currently offer.

TRIP PLANNER QUESTIONS

1. *What market segment are you focused on reaching?*
2. *What do you want to achieve for that market? What problem are you trying to solve?*
3. *What are your methods and metrics for evaluating results with this market?*
4. *What do customers want from your program? Are there unmet needs?*
5. *What data do you have to work with?*
6. *What do you want to do with that data (e.g. types of analysis, visualization, segmentation, etc.)? What channels of communication and other interaction already exist to reach this market?*

SURVEYING THE LANDSCAPE: EXAMPLES OF NEW PROGRAM MODELS

Judging from the name, you might assume that M&V 2.0 is simply an upgraded method for calculating energy savings. You may have heard that it will be faster, cheaper, and more accurate. While these are all selling points for many of the tools available today, the benefit of these tools can reach far beyond the M&V of typical efficiency and demand response programs. And importantly, this new territory of M&V 2.0 is not just for regulated efficiency programs that are incentivized and required through legislation or standards to advance energy efficiency and provide verifiable savings estimates to support their utilities revenue recovering mechanism. Even unregulated programs such as non-utility-run programs or those offered by coops and municipal utilities have funding that typically comes with some sort of accountability and reporting requirements that could benefit from an M&V 2.0 approach.

This section provides some leading examples of how other utility programs are leveraging M&V 2.0 tools and techniques to provide new program offerings or improve existing program functionality. But before we dig into these, it is important to highlight how and why some of these programs differ from current program models, and discuss whether it matters in relation to making cost-effective and scalable program decisions.

In general, the typical profile of today’s efficiency program model remains a direct reflection of the M&V techniques that enable them. They are built upon an estimated average savings and incentive offering per unit/measure, and their impact is calculated through the aggregation of these measures at the portfolio level for each market (residential or commercial) in order to determine a program’s overall impact and cost-effectiveness. Technical Reference Manuals (TRMs) are one traditional M&V tool often required through regulation to support this approach and are also the main source of measure-level deemed values and inputs that are used to calculate savings impacts for “prescriptive” programs. The exception to this rule is large commercial projects that cannot be estimated with deemed methods and are valuable enough to do “custom” savings estimates based on engineering calculations, but this takes a significant investment of time by a trained practitioner.

While TRMs continue to play a valuable role and standardized approach to estimating the savings and planning future impact of many programs (prescriptive rebate-focused or other) from the “measure-up”, the advent of M&V 2.0 tools and techniques and ability to leverage data in completely different ways is not only adjusting the “measure-only” approach for designing program models but also providing real-time energy savings values at scale that can better support the cost-efficiency of these existing approaches. More specifically, it presents a multifaceted opportunity for stakeholders to rethink and redesign how programs are delivered, what is delivered, and how impact is measured.

While there is no one best approach for using M&V 2.0 to support program optimization, the overarching goal is still to generate the most impact per dollar (including both incentives and administrative costs). M&V 2.0 presents new ways to achieve that goal. Still confused or skeptical? As we found during our stakeholder discussions, sometimes the best way to move everyone forward in their understanding of M&V 2.0 is to provide concrete examples of new program models that offer a different value proposition to customers by leveraging M&V 2.0 approaches. We offer a handful below to get your appetite going.

BEHAVIOR

If the goal of your program is to help customers figure out how to better manage their energy use and costs and perhaps increase participation through motivational factors, what about using behavioral psychology to influence consumer decisions? This is one of the fastest-growing efficiency program models today, and behavioral programs such as home energy reports do not rely on engineering estimates to generate a savings claim. Rather, they compare program participants' energy usage before and after program intervention to a control group's usage over the same time periods. This approach, which combines lessons from marketing, social sciences, and behavioral economics to encourage changes in energy consumption patterns and decision-making, is one example of how the advent of smart-devices and growth of user-driven data is providing utilities more opportunities to interact and motivate customers through behavior initiatives. Note that, while the motivators are behavioral, rather than financial, the actual savings could come either through changing the "energy use" behavior (how people operate buildings, such as leaving lights on in unoccupied rooms) or through purchase behavior (upgrading to efficient equipment.)

The comparison group methodology for determining savings also allows the program to be tweaked from year-to-year (rather than waiting for 2-3 years for a formal evaluation to occur), and can support mid-point adjustments to the program design/message or other factors to help increase results. For example, in the case where a large group of customers receives one message and the other group does not (e.g., A/B testing), M&V 2.0 tools that are assessing savings impacts in near real-time can help provide timely feedback that informs program design.

Studies show that behavioral programs can be cost-effective, and scalability is known to improve this further. In addition, behavioral programs are also known to be good market-transformation mechanisms and can contribute to long-term structural shifts in how people use energy and make decisions about energy consumption, shifts that are important beyond the simple kWh or MMBTU saved.[10] As such, large scale behavior-based energy efficiency programs are becoming a relatively well-accepted source of program savings. Rigorous evaluation methods are still being developed to provide the confidence to policymakers around the persistence and validity of these savings.

PAY FOR PERFORMANCE

If the goal of a program is simply to achieve a certain amount of cost-effective load reductions, why not leave the details up to the market actors? This is the idea behind a range of program designs that typically use interval meter data (or even monthly billing data if aggregated to a portfolio of projects to reduce statistical variability) to measure the amount of achieved savings. Dubbed "pay for performance" (P4P), this approach is a wholesale change in how to deliver and pay for efficiency upgrades and has started to receive considerable traction, with several utilities testing various types of P4P pilots, most notable led by PG&E,[11] across the country.

Unlike traditional program M&V that relies on estimations of savings from individual widget/measures, the PG&E P4P model translated the actual weather-normalized reduction in energy use measured at the meter into a dollar-per-MWh payment, regardless of the way the savings were achieved (measures/behavior/other). This encourages

[10] ACEEE Field Guide to Utility-Run Behavior Programs http://aceee.org/research-report/b132

[11] https://www.openee.io/post/pg-e-launches-20-million-residential-p4p

a market-driven approach to load reduction by allowing aggregators to bid efficiency services (contractor work or other) into the P4P program without needing to match up services with specific program tasks or TRM measures. The payments are then paid based on actual savings, and typically made to aggregators or contractors, not to the customers. Customers will benefit directly from the savings made when they reduce their energy use.

These programs require a standard, agreed-upon method for calculating weather-normalized savings. One such method that is currently being testing in California is the CalTRACK methodology, an open-sourced approach to normalizing metered energy consumption using either monthly or interval data from an existing conditions baseline.[12] Such programs also must be designed to avoid “gaming” schemes, where buildings are targeted for inclusion based on an expectation that they will naturally reduce their consumption during the performance period, such as homes with high school seniors.

As the saying goes, if you can measure it, you can manage it, and the P4P model and supporting M&V 2.0 methodology offers a new approach to enabling efficiency markets, and providing transparent accurate savings data to support program implementation, administration and evaluation.

PROGRAM OPTIMIZATION ANALYTICS

Are you hoping to determine how to better use the information you are already collecting from your customers, vendors, and trade allies on what is working and when there are problems? Are you trying to improve contract oversight and engagement in your direct install (DI) or Home Performance with ENERGY STAR® (HPwES) programs? Then you might benefit from adopting program optimization software and analytics that can help you manage these relationships better, reengage customers, and perhaps drive participation and savings increases.

Transforming data that you already have into insights that can help you gain maximum value from your current program offerings and relationships is the basic principle of this approach. And the good news is optimization analytics does not require any change in M&V approaches. Rather, it focuses on improving customer satisfaction, engagement, and participation to increase the cost-effectiveness of a program offering. In short, happy customers stay engaged and refer program participation; unhappy ones drop out and may even discourage others from signing up.

A good example of this M&V 2.0 approach in action is Arizona Public Service’s (APS) use of program optimization software to enhance contractor management and inspections for their HPwES program. By pairing current customer usage data, contractor performance, and weather data on a monthly basis, this software provides valuable feedback to the utility about where to focus inspections, targets contractor issues (based on what measures are being installed), and provides tangible feedback to them on how to improve their business performance.[13] The overall impact for APS has been an approximate 25% reduction in their inspection budget, better contractor relationships, and happier customers, all of which feed into in improved M&V results for their HPwES program.

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[12] http://www.caltrack.org/caltrack.html

[13] http://assets.cdnma.com/7083/assets/EnergySavvy_Case_Study_APS_Program_Optimization_Final.pdf

MASS-CUSTOMIZED MARKETING

Are you interested in delivering salient and impactful offers to each customer to maximize participation and savings? It is possible to target efficiency recommendations at a more granular level than simply segmenting by residential or commercial accounts. This can be accomplished both by using AMI data analytics and also with different non-energy data sets, such as real-estate-parcel-data, demographics, purchase history, or other types of information to help you.

Not to be confused with traditional methods of utility market segmentation based on rate codes and other account attributes, mass-customization in marketing uses advanced data analysis to review and compile multiple energy and non-energy data sets to reveal more-granular and actionable customer information. This information may highlight which accounts are most likely to participate in a program; for example, which buildings are more likely to have particular types of equipment or use patterns that would suggest higher savings potential for specific measures. This information can be used to help program targeting, customer engagement, propensity scores and overall optimization.

This type of M&V 2.0 approach to driving more savings (or other goal metrics) by turning different types of information into valuable intelligence for programs, is not useful solely within the energy industry. Other industries regularly use both public and commercial data sets to build consumer profiles to market the most-appropriate services to different customer segments.

REDUCING EVALUATION RISKS

A commonly voiced concern related to M&V 2.0 activities is that they could create "evaluation retaliation," in that the previously estimated savings based on tradition M&V are not found in the billing analysis, and subsequently, program performance gets reduced, and the utility can even incur financial penalties.

While some pilots have found that M&V 2.0 analysis indicated lower than anticipated savings results, the tools can also help utilities to manage and even improve program performance. To the extent that M&V 2.0 can provide early indicators of savings or lack thereof, this presents opportunities for program designers, providers, and evaluators to look for ways to adjust the program to improve those outcomes. RMI and LBNL's overview, *The Status and Promise of Advanced M&V*[14] provides an effective review. Considered from a risk reduction and program optimization perspective, the benefit of having both earlier and more-granular feedback on a program's performance is positive. Such feedback can help to identify and correct problems, manage budgets more effectively, and communicate impact in a real-time manner.

However, in order to truly reduce evaluation risk, there must be alignment between the program administrator and evaluators about what M&V methods will ultimately be used to determine the program's impact. Getting real-time feedback from an M&V 2.0 system is most useful if that same calculation approach will be used by the evaluator. As an additional benefit, if the program data is already being used to calculate impacts with an automated M&V 2.0 system, that can help to reduce evaluation costs and allow additional focus on qualitative assessments, attribution studies, and other factors that are typically outside the scope of today's M&V 2.0 systems.

[14] https://eta.lbl.gov/sites/all/files/publications/lbnl-1007125.pdf

INDUSTRIAL CUSTOMER ENGAGEMENT FOR OPERATIONAL SAVINGS

Perhaps you are looking for help for your large industrial customers to lower their energy bills, and what to focus on driving operational savings rather than to offering new shiny toys or requiring big incentives and capital expenditure investments.

As a specific example of enhanced customer engagement, Strategic Energy Management (SEM) is a holistic approach to managing energy use. Most typically implemented at industrial and water resource recovery facilities, SEM is also readily applicable to institutional (hospital, schools, university campus) and commercial and multi-family properties. With a focus on low-cost, no-cost operations and maintenances approaches and the use of real-time data to make operational adjustments more responsive, SEM delivers trainings that focus on supporting continuing energy performance and long-term energy, cost, and carbon savings for participants.

In the purest sense, SEM is not an M&V 2.0 strategy in and of itself; it is an engagement tool to be used by account managers to help deepen their relationships with customers and create a culture of continuous energy improvements and de facto savings at their facility. The M&V 2.0 approach comes into play with the add-on of tools that are used to calculate savings that stem from operational improvements and provide visual feedback to customers on their site's energy use and performance in near-real time. Commonly termed real-time energy management, or energy management information systems, these tools provide monitoring and diagnostic support of a buildings energy systems and can help support significant energy savings at a site.

Regression model analysis is another tool used to estimate the energy savings associated with SEM-related activities, by modeling a facility's energy consumption and the corresponding variables that drive its energy use (production, weather, waste, occupancy, other non-energy data etc.). This evaluation approach is well documented by Uniform Methods Project (UMP) protocols[15], and there are a significant number of both SEM vendors and programs examples that can provide insights of how to deliver SEM and calibrate the impact of this approach – for example, Bonneville Power Authority, the Energy Trust of Oregon, Efficiency Vermont, and NYSERDA all provide SEM programs for various industrial customer groups.

SMB BEHAVIORAL MESSAGING / OPERATIONAL OPTIMIZATION

Perhaps you are looking for a more-scalable SEM-like approach for your small and medium business (SMB) customers that leverages some data visualization of marketing materials, along with "self-serve on-line learning", rather than the in-person training and workshop commitment required through traditional SEM. "SEM-lite" program offerings have been designed that use customer interval data to generate customized reports, energy-saving recommendations, and calls-to-action to help customers manage their own energy use.

As with formal SEM programs, M&V 2.0 contributes to the measurement of the impact and estimated energy savings of this strategy through a randomized control trial (RCT)[16] of the "encouragement" program-design features – in this case, the SMB customized fliers. There are numerous examples of utility programs using this type of targeted marketing approach and RCT methodology to derive their program's true net energy savings. While this is similar to the residential behavioral program approach, it not only requires different calculations and

[15] https://www.nrel.gov/docs/fy17osti/68316.pdf

[16] The Case for Randomized Controlled Trials in Evaluating Energy-Efficiency Programs https://e2e.haas.berkeley.edu/pdf/RCT_Primer.pdf

messaging, but it might also require different M&V techniques. SMB cohorts may not be large enough to support a basic RCT approach, and can require weather-normalized savings estimates instead or in addition.

REMOTE AUDITS WITH MEASURE RECOMMENDATIONS AND INTEGRATED M&V

The power to support audits remotely by using software-based data analytics of existing daily, monthly, or interval energy usage data can present numerous benefits to a program. Remote audits can consist of as little as an online survey, or they may add data from real estate and tax databases, satellite images, census, utilities, and other data sources that help an algorithm predict energy use and opportunities for improvement. This approach can help increase compliance with federal standards, produce a standardized approach to audit reporting of useful information, lower the time and cost of providing “boots on the ground” verification, and preserve data for future reporting, portfolio-wide tracking, and re-use. While most remote audit technologies are designed for residential buildings, there are a few that can serve commercial customers.

In addition to audits driven by energy-use data and home asset surveys, there are remote audits that require only a home address, which are then correlated with publicly available data sets in order to estimate annual energy use. A 2018 report by the Rocky Mountain Institute found that these estimates are within 20-30% of the more in-depth DOE Home Energy Score.[17] These automated energy use estimates could be viable for supporting homebuyers, energy service contractors, lenders, and government agencies to incorporate energy costs into their investment or policy decisions.

WEB PORTAL / MOBILE APP

An even simpler approach to leveraging the power of your customers’ data, connected devices, and communications channels that already exist is to extend an online bill-pay portal to include efficiency recommendations and behavioral messaging that can produce measurable savings.

The DTE Energy Insight app[18] for residential customers provides just this, delivering energy efficiency savings tips alongside an app that syncs with a customer’s smart meter and allows them to make instant decisions to change energy consumption, set personal targets, and respond to weekly challenges. For those jurisdictions where managing electricity demand is a concern, leveraging these communication applications can help to provide not only the efficiency savings from a customer’s perspective but also provide demand response opportunities for the utility by asking customers to either reduce or shift their use of energy to a different time of day.

These examples provide a range of ways that M&V 2.0 can apply to your programs, as well as the potential benefits that can result. And, as illustrated, the opportunity to leverage M&V 2.0 analytical power or innovative technology does not always lead to or require a new or separate program design feature. So, as you think more about what you are trying to accomplish, keep in mind the following questions, as the answers may help direct you to an approach outlined above, or a combination of a few!

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[17] Hopkins, Greg and Jacob Corvidae. MPG for Homes: Accuracy and Application of Automated Home Energy Estimates. Rocky Mountain Institute, 2018. http://info.rmi.org/MPG_for_Homes

[18] https://www.newlook.dteenergy.com/wps/wcm/connect/dte-web/insight/insight-app

TRIP PLANNER QUESTIONS

1. *Are there portfolio-wide goals such as total kWh or peak kW savings that the program portfolio needs to boost?*
2. *Are there any types of customers or trade allies that have been challenging to engage with the past? (see also "Choosing a Destination")*
3. *Are there aspects of the program that have been unpredictable in the past, or would benefit from faster feedback to program staff?*
4. *Where do projects often get "stuck" or abandoned by customers in current programs? Are there documentation requirements that participants find burdensome or are unable to complete reliably?*
5. *Are there services that customers are asking for which have savings potential but don't currently have a way to garner program support?*
6. *Are you aware of decision points in the energy use life cycle of buildings that would be an ideal time to intervene, but which don't lend themselves to current program models?*

CHARTING A COURSE: SELECTING AN EFFICIENT TECHNOLOGY/MEASURE

From a program offering perspective, one of the benefits of M&V 2.0 is that these new techniques for estimating and verifying savings can also enable programs to offer technical support and incentives for new innovative products and services. Innovation itself is a process that helps to make things possible that once seemed impossible, and M&V 2.0 analysis is a central innovation to supporting new measures or services that do not lend themselves to traditional methods of calculating savings. It can allow programs to fund initiatives that could not be deemed cost-effective because there is too much variability in impact from one project to the next or where there are sources of uncertainty that make it difficult or impossible to include the measure in a program. Such variability or uncertainty can manifest as high costs associated with estimating, screening, measuring, or evaluating savings, or high risk of variances in program performance that cannot be detected in time to mitigate.

For example, products such as “building energy management systems” or services like “building retro-commissioning” might be marketed as a standardized commodity and might even list a promised energy savings amount, while in practice they can provide radically different levels of savings for different customers depending on how they are implemented and the prior state of building controls. Conducting a market study on such measures would require a huge sample size to produce a reliable estimate of average savings. Even then, a program would face risks that implementers could make small changes from project-to-project that would create a risk that achieved savings are very different than estimated savings, making the program difficult to budget and manage reliably. Using M&V 2.0 techniques could allow customized savings estimates for each customer that would limit risk to programs while offering attractive services to customers and sending clear market signals about maximizing the value of energy savings for each customer when delivering these services.

Another opportunity for M&V 2.0 is that it offers a way for program implementers to respond to customers’ requests for new services or measure support, or to rethink the impact of current measure offerings.

To help you better respond to questions of what measure or technology might best be supported by M&V 2.0 for you, in this section we provide an overview of the opportunities afforded by using data, analytics, connected devices, or other M&V 2.0 techniques or technologies to:

1. Improve M&V of measures previously considered “too hard to handle.”
2. Include new measures perhaps requested by customers.
3. Claim higher savings from an existing measure, in those cases where a lower savings estimate might have been used to mitigate risk from an uncertain savings value using conventional approaches.

The table below provides examples of emerging technologies, services, or specific energy conservation measures that fall into one or more of the three categories above, a review of which market sector they are applicable to, and what service/benefit they can provide.

Table 2: Emerging Technologies That Can Support M&V 2.0 Activities

Technology	***Residential***	***Commercial***	***Industrial***	***Description***	***Detects waste***	***Provides feedback***	***Produces EE impact***	***Produces DR impact***	***Measures savings***
Home automation / smart home	X			Internet-connected lighting; controllable appliances and outlets; apps and services for managing.	X	X	X	X	X
Building automation system (BAS)		X		Networked building monitoring and controls system for scheduling lighting and HVAC controls.	X	X	X		X
Building energy management system (BEMS)		X		Networked building monitoring system (typically without controls) for analytics and fault detection.	X	X			X
Real Time Energy Management (RTEM)		X	X	Real-time energy monitoring dashboard with modeled baseline to track performance improvements from engagement activities.		X	X		X
Compressed air or industrial process monitoring			X	Air compressor power and flow metering measures system efficiency in real-time and monitors leaks and savings over time.	X	X			X
Home weatherization program support tools	X			Remote audits for targeting and engagement; automated M&V from billing / AMI data analysis for program optimization.	X	X			X

Technology	Residential	Commercial	Industrial	Description	Detects waste	Provides feedback	Produces EE impact	Produces DR impact	Measures savings
Smart thermostats	X			Improves HVAC control with occupancy detection, weather forecasts, remote controls and machine learning; measures HVAC run-time to model schedule and equipment efficiency; models shell performance using indoor temperature.	X	X	X	X	X
Smart HVAC controls		X		Retrofit or manufacturer-supplied sensors and controls can add demand-controlled ventilation to existing RTUs.			X	X	X
Building modeling software	X	X		Software such as Open Studio automates model generation for estimating energy use and savings potential from changes.	X				X
Building energy reports	X	X		Uses utility billing or AMI data to generate mass-customized reports with savings recommendations; uses control groups.	X	X	X		X
Non-Intrusive Load Monitoring (NILM)	X			Measures electricity use for individual loads by disaggregating from the whole-house meter.	X	X			X

How do you use this information effectively to help you better answer which measure could best support your program's impact, savings goals, or evaluation requirements? Or do you just need a new M&V approach to garner better data-driven results from your existing measure mix? Or, as the technologies listed above illustrate, do you want to introduce an efficient product that provides additional data and makes the savings calculation possible itself?

If, for example, you want to support a weatherization program, offering a smart thermostat incentive may be a path to targeting and verifying more savings. In addition to any savings the smart thermostat provides on its own, its data can be used to calculate weatherization potential and verify the level of improvement on individual projects. This sort of automated, project-specific savings calculation can enable pay-for-performance or incentives for DIY projects whose savings could not otherwise be estimated. While the insulation may be "dumb," the measurement can be dynamic, and rather than assuming that a checklist of measures is adequate to estimate savings for a program, you can overlay billing data and smart thermostat data to estimate baseline performance and impact of air-sealing and insulation efforts.

Note that in some cases there is also a subtle distinction between novel products and services that can be built onto a standard program like "additional features" that provide added value to a program, and novel program models that provide value in a completely different way. For example, the service of retro-commissioning and the program model of pay-for-performance might be two sides of the same coin. Some products and services do not currently fit into standard program models where an incentive is offered per installed unit of a product, so a new program model is needed in order to offer these products. For more discussion of M&V 2.0 program models, see "Surveying the Landscape."

There are a number of questions associated with determining what measure or tool will best support your new or existing program. During our stakeholder meetings and discussions, it was challenging to tease out the important components, given there is no one right approach or answer to which M&V 2.0 technique or technology might best fit. It proved helpful to focus attention on the trip planner questions below, with the caveat that you need to engage with internal (customer service, IT) and external players (regulators, customer advocates, evaluators), so get buy in early!

TRIP PLANNER QUESTIONS

1. *What product or service is of interest to your customers, but you are not currently able to support with standard savings estimates or M&V techniques, at least without risking budgets or evaluation schedules?*
2. *How might you use traditional M&V tools to screen this technology, qualify users for participation in a program, estimate and claim savings for measures delivered, and evaluate the results at a program level?*
3. *What challenges does this technology present under traditional M&V methods when creating an engineering model to calculate savings, characterizing sources of between-customer variability, recognizing variation in performance between product models, tracking program performance, and evaluating program results or attributing savings? This might include sources of uncertainty that make it difficult or impossible to include the measure in a program, high costs associated with estimating/screening/measuring/evaluating savings, high risk of variances in program performance that can't be detected in time to mitigate.*
4. *What are the opportunities for using data, analytics, connected devices, or other M&V 2.0 techniques or technologies to improve M&V of these measures so that these challenges can be overcome? What benefits would you hope to gain, and how would you evaluate those benefits? Would they be represented as*

reduced M&V costs, reduced program risk, the ability to include new measures or claim higher savings from a measure?

5. *How can you score potential M&V 2.0 solutions based on their ability to deliver these benefits? How do you know if they solve the existing problems adequately to open up the ability to support a new measure, or if the cost of the new solution is justified by the savings to M&V activities?*

STRETCHING YOUR LEGS: TRYING A PILOT

Are you eager to launch a pilot of your own, but need some information on how to get started? Nothing beats first-hand experience. In this section, we will review some key considerations on how to get the most out of a pilot, starting with how to successfully lay the groundwork for a field test within your organization and get management support. We provide some recommendations on how to plan for success once you are up and running, stay focused, prioritize the most important questions you have to test, and learn from your mistakes. Some of this advice will be familiar to anyone who has experience launching a technology-heavy pilot or program, but some is specific to the challenges associated with M&V 2.0.

PLAN FOR THE LONG HAUL: THE PILOT STUDY AS THE ON-RAMP TO THE PROGRAM

Pilots can be useful, but in recent years have earned a bad reputation among many vendors, as utility programs often seem to use pilots to "kick the tires" without showing any real intention to adopt the technology at scale. While this approach may allow the program to say they are innovative, it may not bring much value to customers, nor support any real or meaningful opportunity for program innovation. Indeed, some technologies will wash out in the pilot stage, and it is less costly and less disruptive to learn those lessons at a small scale. But how do you get sufficient buy-in to launch a pilot or demonstration project that will be supported at the next step, and prove valuable from the onset?

As a starting point, in addition to this section's discussions below, we encourage you to read the Rocky Mountain Institute's in-depth report on the role of Distributed Energy Resource (DER) pilots and demonstration projects in reinventing the utility business model[19], as there is considerable overlap between the issues and challenges encountered with DER pilots and M&V 2.0 pilots. EnergySavvy's guide[20] to making the case for and getting started on M&V 2.0 is another good source of information and provides step-by-step guidance on moving forward, similar to what is outlined below.

CONTEXT AND FRAMING: ALIGNMENT WITH ORGANIZATIONAL GOALS

While this advice is by no means unique to planning a pilot, it is essential to tie the specific exercise of planning a pilot to the larger organizational goal it is serving. Is the pilot objective to meet savings goals, reduce risk in the measurement of savings, increase customer satisfaction, or adapt to a changing technology landscape? How does this tie into the broader business's goals? Sometimes the request for a pilot comes as a pointed imperative from management, or perhaps there is R&D funding that has been allocated in advance. Perhaps someone saw a compelling new technology demonstrated, and just wants to check it out. While M&V 2.0 encompasses lots of nifty gadgets and apps that are intriguing, it is important to ensure that your request to test them is clearly articulated and framed by a genuine and relevant objective. The exercise of asking "why do we want to do that?" repeatedly can be helpful in moving away from the attractive characteristics of the technology and focusing on what the unmet needs are that you think the technology can offer. In the best-case scenario, the clear articulation

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[19] *Pathways for Innovation: The Role of Pilots and Demonstrations in Reinventing the Utility Business Mode* https://www.rmi.org/insights/reports/pathwaysforinnovation/

[20] EnergySavvy's guide "Advanced M&V: Six Steps to Getting Started" http://assets.cdnma.com/7083/assets/EnergySavvy_Advanced_M%26V_Getting_Started_Guide_Final.pdf

of a pilot's goal and content secures the internal support and buy-in critical to moving this idea forward as part of a larger strategy.

Alignment with goals is an interactive exercise: not only do you need to elicit the purpose of the pilot from whoever requested it (or examine your own motives if you had the initial inspiration), but you also need to communicate it to stakeholders. It is important to have buy-in from leadership, so think about what values your organization has and how M&V 2.0 pilot might also deliver these. Ideally, you want the support to not only carry you through to a successful conclusion of the pilot, but also to take what you learned and apply it to improving future programs, or offering new program opportunities by scaling the pilot up to full-scale.

In addition, there are numerous other stakeholders within a utility program (and perhaps even outside if collaborators or contractors are involved) that will need to support your pilot, such as program managers, customer service, IT/metering/billing, and marketing staff, plus implementation or field staff that will interact with customers. Also consider parties that may not be involved in the execution of the pilot, but have an interest in the program's goals and might review or intervene as the pilot proceeds, particularly if you need them to support the pilot's conclusions and recommended next steps. Outreach to all these stakeholders should include not only education about how the pilot is working to advance the larger program goals, but also what specific things you are trying to learn through the pilot.

DEFINING THE TEST: WHAT DO YOU WANT TO LEARN?

The primary reason for running pilots is that there are key questions that cannot be answered without a field test, or you need to work out the kinks of a new process before taking it to scale. However, if there is no clearly articulated question being tested or a jumble of multiple things, a pilot will likely end without being able to inform a decision. The best questions include not only a clear test, but also a quantitative metric, such as: "How much time does this new technique save?" or "How much do meter-based savings estimates differ from traditional techniques?" or "Can our IT department create a continuous stream of usage data to our M&V 2.0 vendor?" Sometimes the test includes not just outcomes, but also the program's ability to support the data requirements to incorporate the new technology in practice. The test should be clearly stated in the plan, along with the method for measuring it and perhaps even the threshold for success.

If the pilot involves a new energy-saving technology, the test might simply involve calculating savings to see if it is cost-effective, but if you are piloting a M&V technique, it might be treated as a process improvement. In the latter case, it may also be necessary to run a traditional M&V technique in parallel so that the new measurement can be compared to the old measurement.[21] In some cases, the pilot might be simultaneously testing a new measure that also requires a new M&V approach (for example, behavior programs). In such cases, it is even more important to use the principles of experimental design and carefully construct a logical chain of proof to build up to the final conclusion.

When you get a new toy, you sometimes just want to push all the buttons at once to see what happens. Similarly, when you get permission to test out a new technology in the field, it is tempting to answer as many questions as

[21] We will caveat that without a standard calculation method, it is a well-accepted notion in the industry that independent energy savings analyses will often result in different results, leaving the project sponsor with little valuable information. In many cases it is better to have an independent review of methods and calculations against known best practices, guidelines and protocols.

possible. After all, you might not get the chance to put something in front of customers again, and there might only be enough time and budget for a small number of pilots each year. So why not try to make the most of it and hit all the bases: technical functionality, savings potential, measurement accuracy, customer satisfaction? You might want to test a few variations for things like incentive level, marketing method, or combinations of technology that might interact with one another. It is certainly possible to learn multiple things from a single pilot, but there is also a risk that trying to pack in too much can result in a poorly executed pilot or undermine the clarity of results. Unless your pilot has a boundless schedule and budget, it is best to prioritize the most-important questions and focus on answering them as clearly as possible. This might require constructing treatment/control groups, or another kind of A/B test that isolates the effect from other sources of variation. Remember that layering variations in the treatment (such as looking at the impact of several different targeted messages on high and low energy users) divides the number of participants into more sub-groups and can dramatically reduce sample size. Smaller samples are less likely to be able to detect as subtle an effect as a larger sample can. However, segmenting the population into self-similar groups can amplify the effect within each group, though it can be hard to know what factors will be correlated with effect size before running the pilot.

MEASURING YOUR YARDSTICK: TESTING A NEW M&V TECHNIQUE

Sometimes we need to test the accuracy of the new M&V technique itself. On the surface, this might seem straightforward: just compare the new method to the tried-and-true, then see if they get the same answer. That outcome might be desirable, but it is unlikely for a number of reasons.

First, it is possible that the traditional form of M&V is measuring something slightly different than the M&V 2.0 approach. An obvious example is deemed savings for a code baseline measure compared to pre-post metered savings, which assumes an existing-conditions baseline. This is a fairly clear example of a mismatched comparison, but there are many more subtle ways that one or the other technique includes some alternate assumptions or uses a different boundary for analysis, and so are not directly comparable. In some cases, one or both results can be adjusted to make the comparison fairer, but sometimes a third technique should instead be used to estimate the "true" answer against which to judge the M&V 2.0 technique. This typically requires the use of techniques that would be too expensive or invasive to use for all projects, such as in-depth site surveys, sub-metering the affected building systems before and after the measure is installed, or performing detailed engineering calculations or creating physics-based building models.

A second source of variation comes from the statistical nature of many M&V 2.0 tools. Many of these methods involve using large amounts of data about each project, then fitting a numerical model to the data. The result includes not only an estimate of the average or most likely impact, but also a range around that answer. This is called a confidence interval, an uncertainty range, or an error band, depending on the method used. These may seem like an admission that the results are less definitive than the point-value savings figures provided by TRMs and even many custom project reports. This is not actually the case, however; engineering estimates also typically contain some level of uncertainty, as the actual impact will vary due to differences in the actual run hours, baseline wattages, and other factors that are found in the participating buildings compared to market-wide estimates used for deemed savings figures. Because such uncertainty should theoretically have already been reduced to an acceptable level before those deemed savings estimates are published, the uncertainty statistics are not usually included along with the averages, if they were even calculated. On the other hand, each project's usage data can contain a different level of variability, and the uncertainty metrics are useful for determining whether the "signal" of energy savings can be effectively determined over the "noise" of that variability. So both approaches are actually estimates with some level of uncertainty around the reported average, and should be compared as such.

PILOTS: PRO TIPS AND PITFALLS

STAY FOCUSED: DO NOT TRY TO GET EVERYTHING RIGHT ON THE FIRST PASS

When planning a pilot, there is a temptation to answer all conceivable questions about the technology, market, and engagement approach all at once. Sometimes this is driven by a desire to limit the number of pilots and ease the burden on customers or the budget. Sometimes it is a matter of satisfying stakeholders, who will be more willing to support the pilot if there is something in it for them. This often results in multiple subsets of participants who get different variations of the technology, the promotional material, incentive levels, or other aspects of a potential program that might need to be tweaked. It might also result in a pilot that is trying out several untested aspects at once, such as the program design, engagement channel, and M&V method.

However, a pilot is essentially an experiment to prove out the answer to a question that is standing in the path of a full-scale deployment. If the pilot includes multiple novel aspects because you are certain that the pilot will only work if all these aspects are successful, then it might make sense to test the whole program design in one pilot. On the other hand, if you hope to learn how innovations in multiple aspects of the pilot can provide benefit independently of one another so that you can make recommendations about which one(s) should be adopted, then combining these aspects into a single pilot makes it much more difficult to distinguish the impact of each one.

Sometimes there are multiple problems that need to be solved, such as:

- How do we get customers to adopt this new technology?
- How do we gather data from the technology?
- How do we analyze data from the technology to estimate savings?
- Is that savings cost-effective?

It might still be better to design several small pilots so that, if one aspect proves challenging or even fails, it is clear what your barrier to success is. Then you will have a better chance of making use of the successful aspects while you look for solutions to the remaining problems.

ANTICIPATE THE UNEXPECTED: TECHNOLOGY CRISES AND CUSTOMER FEEDBACK

If we are really testing something that you do not already know the answer to, or are trying something new, it is likely that you will have some failures and discover some problems along the way. After all, that is the point of a pilot: make your mistakes on a small scale, before you launch the full program. Knowing that problems are likely, it is important to make sure to build time and potentially extra resources into the pilot schedule and budget to ensure you can resolve these in a timely manner. For example, if you are launching a smart thermostat program and customers call up with questions about how to link their communicating thermostats with their wireless routers, it is helpful to have some internal or external resources lined up as part of the pilot team that have the expertise to help with questions about configuring Wi-Fi networks.

Similarly, because testing a new technology might not always result in a positive experience for the customer, giving customer service representatives a heads up about a pilot can help ensure that they are best equipped to handling any customer complaint, and can redirect them to further technical assistance. It also makes sense to prepare customers participating in the pilot and acknowledge in advance that they play an important role in helping to figure out the kinks in the system (unless you determine that such knowledge would taint the results of the study). You may even want to offer them an extra participation incentive to participate (unless you are testing incentive amounts or customer satisfaction) or some other form of recognition. While such planning will not prevent problems from happening, they can avoid a fire drill every time something does not go as planned.

REPORTING TO REGULATORS/EVALUATORS/OTHER STAKEHOLDERS

Along with the core goal of proving your exciting new M&V 2.0 program model so that it can scale up, a pilot should generate a more-detailed answer for stakeholders than simply "it worked!" Even if the pilot fails, there may be many valuable lessons that the program team can use when planning future pilots and programs. Sharing these lessons with regional and other industry partners can help others avoid making the same mistakes or replicating your tests in their territory. This may not bring you immediate benefit, but if they later test out a different model or build on your work to answer other questions that your pilot was not able to, then you can both move forward faster.

As noted at the beginning of this section, if you plan ahead and define your pilot's research questions early and articulate how it will answer them, you are more likely to get buy-in at your organization from department heads and upper management. The same goes for ensuring buy-in from external stakeholders such as regulators, customer advocates, or others who may have a say in the future of the program.

If you also use the early planning steps of a pilot design to think through the evaluation process at the end, you help avoid unpleasant discoveries that might have been easily resolved. For example, you might include another question on a survey so that you can analyze results based on a demographic factor or some other metric. In short, by engaging external stakeholders early and often in the pilot's design, you better understand all their questions about the pilot, and it will be easier to discuss and agree to the tradeoffs involved in ensuring everyone is supportive of how the pilot is scoped.

CAPTURING UNPLANNED LESSONS

In addition to answering the core research objectives and the overarching "does it work?" question, there will undoubtedly be many smaller lessons learned along the way. Some of these are the solutions to technical problems, communication glitches with customers, and other minor stumbles that you can correct before scaling up to a full program. Other lessons might be completely unexpected, such as when customers report unanticipated benefits of your new technology, or if an analysis technique reveals useful information about something else going on in the building. These discoveries come in many different forms, so it is best to capture them in a fairly flexible format so you can include all relevant information such as narrative about what happened, source data, screen captures, and photos.

When it comes to testing out a transformational initiative before you jump in headfirst, do not forget to ask yourself the following questions to help manage a successful process along the way.

TRIP PLANNER QUESTIONS

1. *What are the organizational or program goals that your pilot (or the technology it is testing) is serving?*
2. *What is the new M&V 2.0 tool, technology, or technique you are testing?*
3. *What are the key questions that your pilot will answer?*
4. *How will the answer to those questions be calculated or determined? How will they be communicated?*
5. *Who (what individuals or groups) will need to support the pilot in order for it to succeed? Which of them will be decision-makers and which simply need to be informed? Be sure to consider stakeholders outside of your organization such as regulators, trade organizations, customer advocates, etc.*
6. *What are the biggest risks to the pilot's ability to produce a valid and meaningful answer to the research questions being posed? What can you do to lessen these risks?*

RULES OF THE ROAD: REGULATORY CONSIDERATIONS

Introducing a whole new M&V paradigm involves not just justifying the cost-effectiveness of some new technologies or approaches, but also justifying the validity of a new process for calculating the savings. Should utilities wait for direction from regulatory bodies on how best to apply and use M&V 2.0 as a resource, or should regulators wait for pilot results to determine what rules to put in place? Is there a middle path? Can utilities work in unison or on parallel paths to understand how to use data-driven, automated methods to measure energy efficiency in real time?

While there is growing interest, and focus on M&V 2.0, a lack of confidence in the results is still one of the fundamental barriers to its deployment as a resource for evaluators and program planners. While there are a host of various M&V protocols and approaches to calculating savings (many outlined in this report), the lack of common standards to measure energy efficiency across the industry is a key obstacle to the future adoption, investment in, and scaling of M&V 2.0. Another is the clear articulation of goals and collaboration of regulators or those stakeholders that can influence the success of a new initiative or whose support will be needed to implement. Program administrators often approach M&V 2.0 as a one-for-one replacement of our current M&V tools, a simple upgrade to make it faster, cheaper, and more accurate. But while we still need to have high standards for accuracy and reliability, comparing savings results from M&V 2.0 to our current engineering estimates may not be the best way to assess them.

These challenges are being wrestled with in a variety of ways. This section seeks to highlight a handful of examples of activities underway around the country that can help guide the use and evaluation of software tools in the industry. It also provides valuable reference points on how to successfully integrate M&V 2.0 techniques, applicable to both regulated DSM programs (that require evaluation in order to determine the efficiency and efficacy of their programs), as well as unregulated programs, such as non-utility-run programs or those from coops and municipal utilities, that also have to demonstrate the cost-effective of their activities to members, funders, or other bodies.

ORIENT TO TRUE NORTH BY ALIGNING WITH THE PROGRAM GOALS

One reason that it is hard to directly replicate the function of today's M&V tools as they are used to support common program models such as product rebates is that the programs are in some sense a reflection of the tools. Historically, gathering data about efficient equipment performance was an expensive and time-consuming process, requiring lengthy field studies with expensive monitoring equipment and custom engineering analysis. Broad-based prescriptive programs that offer a fixed rebate for standardized equipment replacement are designed to deliver a large pool of projects that, on average, correlate with the results of those studies: average run-time, baseline wattage, and so on. In fact, many aspects of program implementation are rooted in this process, starting with deemed savings factors that are determined based on market studies and engineering calculations, full of estimates and assumptions that must be approved by the program's funders before it is launched. The goal of all these determinations is to ensure that, on average, the program's overall benefits will exceed its costs.

M&V 2.0 methods may not be able to produce the same results for the same kind of program, but that may be because the programs we have grown accustomed to are not the best application for these approaches. The real test is whether they can measure the energy impacts of program activities to a degree of accuracy and reliability that allows program funders (typically the ratepayers, as represented by regulators and overseen by evaluators), program administrators, and program implementers to all plan and track program performance. This does not require that we abandon the fundamental goals of a program, as represented by the chosen cost/benefit test and other key performance indicators that are used to measure program success. Ultimately, those high-level goals are what should matter to regulators. Rather than clinging to the established metrics and milestones for existing M&V processes, try to establish the connection between your proposed M&V 2.0 solution and the high-level program goals, then work with regulators to establish tests that give all parties confidence that the results will be meaningful, reliable and consistent.

BRING THEM ON THE JOURNEY WITH YOU BY PLANNING AHEAD

Regulators may have some goals that they feel are not being adequately met or have some specific challenges or opportunities that might be served with M&V 2.0 techniques. They may also have some concerns about introducing M&V 2.0, whether it be with the accuracy of the results, reliability of new technology, or potential changes to customer experience. If those concerns and opportunities are understood at the beginning of any studies or pilots, they can be better designed to address the concerns or test out the viability of achieving new opportunities of interest. Also, if the cost of evaluation is a well-known concern, to the extent that M&V 2.0 can be proven to reduce those concerns, regulators and evaluators alike will appreciate these benefits.

FOLLOW IN THE FOOTSTEPS OF OTHERS WHO HAVE GONE BEFORE YOU

You do not have to reinvent the wheel or expect your evaluators and regulators to do so either. There are a variety of activities underway around the country that can help guide the use and evaluation of software tools in the industry. Taken together, they are creating a body of experience and thought leadership that is incredibly useful to all stakeholders faced with decisions about how to judge the performance or applicability of M&V 2.0 technologies and the results they generate.

Work revolving around CalTRACK and CalTRACK 2.0's M&V standards seems valuable to follow. CalTRACK supports California legislation (AB-802 and SB-350) by calculating whole-building site-based savings that result from any mix of measures, building types, and consumer behavior. CalTRACK does not estimate the amount of savings that can be attributed to a particular measure and does not take the place of program evaluation. Calculating site-based, weather normalized metered energy consumption (NMEC) and savings is often a first step in a program evaluation. Other steps consider additional variables. However, CalTRACK allows third-party energy efficiency program implementers to conduct energy savings analysis on their own customers themselves, provided they are given access to their customers' energy consumption data via Green Button or other means. This ability to track program performance creates opportunities such as baking continuous improvement into programs and for aggregators to quantify their expected yields for Pay-for-Performance programs.

The Northeast Energy Efficiency Partnerships (NEEP) has also assembled a list of case studies for both commercial and residential program applications of Advanced M&V[22]. The list includes New York's REV proceedings, which encourages the use of M&V 2.0 tools and techniques, and Connecticut's work with the U.S. Department of Energy and LBNL to test M&V 2.0 methods in comparison to conventional M&V methods.

[22] Auto M&V Industry Brief: How Fast is the EM&V Paradigm Changing?, December 2016

There is a need to develop open industry software standards that can support the interoperability of these approaches and a generally accepted test protocol for validating M&V 2.0 software that is developed and supported by evaluators and industry alike and can support a comparable metric anywhere in the US.[23]

STAY ON THE BEATEN PATH BY FOLLOWING STANDARDS

While M&V 2.0 is still considered an emerging field, it did not materialize out of thin air. Existing techniques like IPMVP Option C address best practices for calculating whole-building energy savings using billing data, a technique that underlies many of the automated M&V tools. ASHRAE Guideline 17 takes this approach a step further, detailing specific calculations and thresholds for accuracy. The US Department of Energy has developed guidelines for calculating savings of specific measure types through the Uniform Methods Project (UMP).[24] Several chapters of the UMP are particularly applicable to emerging M&V approaches, such as: Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol; Chapter 16: Retrocommissioning Evaluation Protocol; Chapter 17: Residential Behavior Evaluation Protocol; and Chapter 24: Strategic Energy Management (SEM) Evaluation Protocol. Other frameworks include the ISO-NE Forward Capacity Market's Manual for the Measurement and Verification of Demand Reduction Value from Demand Resources, which provides guidance and required criteria for the M&V of capacity performance of demand resources, including energy efficiency and demand response, participating in New England's wholesale electric markets.

While perhaps none of these standards are mature enough yet to enable the true scalability of M&V 2.0 in a replicable and interoperable manner under a "one-M&V 2.0 standardized approach,"[23] independently they can provide the regulatory guidance and support you need. Emerging standards such as CalTRACK are also beginning to specifically address M&V 2.0 tools and techniques.

DO NOT BE AFRAID TO TAKE A SHORTCUT

Because of the existing precedent for claiming savings for traditional measures, it may seem easiest to prove that you can upgrade the existing M&V method. However, traditional methods were developed to accommodate efficiency measures that are relatively consistent (e.g., lighting, appliances upgrades, HVAC systems, etc.) using data that can be very expensive to acquire (through lab and field studies).

M&V 2.0 is a response to connected, dynamic devices that produce a lot of data about every single unit installed. We should not assume that the same type of model, with baseline minus efficient wattage times run hours, will still be the most reliable way to calculate savings. Why invest in a single authoritative field study to characterize a technology that will be upgraded by the manufacturer multiple times per year over the product lifetime, when you could use data from actual installed devices that can be automatically updated every year?

These new techniques will have both strengths and weaknesses relative to the prior approaches, but we should look for ways to take advantage of the particular assets and challenges of these 2.0 devices, and measure potential solutions against their ability to inform program operations. If there are regulatory requirements that are at odds

[23] For more information see EnergySavvy's July 2017 White Paper "Getting Real On M&V 2.0 Standards" http://assets.cdnma.com/7083/assets/EnergySavvy_White_Paper_Getting_Real_On_M%26V2.0_Standards_Final.pdf

[24] https://energy.gov/eere/about-us/ump-protocols

with such a solution, try to engage regulators early on and demonstrate that the new technique will meet the underlying needs behind those requirements, if they can't be proven equivalent to the old requirements.

TRIP PLANNER QUESTIONS

1. *Who are all the stakeholders that need to support the adoption of M&V 2.0 in order for it to be successful?*
2. *What are the goals and concerns of regulators and other stakeholders, regarding the cost and performance of the program?*
3. *What benefits are you trying to achieve with M&V 2.0, and how do they help to improve program outcomes? Will these improvements be captured by existing performance metrics?*
4. *What do stakeholders find exciting or risky about the new technologies you are considering?*
5. *If there are concerns about the cost, accuracy, or other aspects of adopting M&V 2.0 technologies, what sort of research or pilot project would be needed to address these concerns?*

M&V 2.0 is no longer just a buzzword thrown around at conferences, or a catch-all term for "what's next" in M&V. Efforts at piloting, developing, verifying, and defining M&V 2.0 are underway in labs, industry, advocacy groups, universities, standards organizations, and city, state, and federal energy-efficiency programs. The table below provides a sampling of those organizations leading the way in research in this field, along with a listing of current M&V 2.0 Protocols and Standards and advocacy groups that are supporting data-sharing practices. We hope you will use this list to help further orient you to this fast-evolving and growing body of work, with links to deeper dives for the areas of particular interest and relevance to your needs.

Table 3: Leading EM&V Research and Advocacy Groups

Organization	Key Project of the Group	Description of the Project
Lawrence Berkeley National Laboratory's Building Technology and Urban Systems Division	2014-2017 Assessment of Automated M&V Methods	Overview of LBNL's work on M&V 2.0 with links to presentations and reports
US Department of Energy's Office of Energy Efficiency and Renewable Energy	Testing the M&V 2.0 Value Proposition	Currently in-progress study (a collaboration of DOE, NEEP, LBNL, CT-DEEP, and multiple CT utilities) billed as the first open, unbiased, large-scale study of M&V 1 vs 2
Rocky Mountain Institute (RMI)	The Status and Promise of Advanced M&V	A 2017 report on the state of adoption of M&V 2.0 techniques in the industry, with discussion of issues to be considered that could accelerate its adoption and to get the most benefit from it
Northeast Energy Efficiency Partnerships (NEEP)	The Changing EM&V Paradigm	*Overview* of industry trend toward "automated M&V"
State and Local Energy Efficiency Action Network (SEE Action)	Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations	Guide to designing and evaluating behavior-based programs - applicable to various programs that measure savings based on statistically-measured impacts at the meter.
Mission: Data		Advocates for Green Button and data sharing
Smart Grid Consumer Collaborative		A non-profit organization promoting grid modernization

Organization	Key Project of the Group	Description of the Project
Open Energy Information (OpenEI)		Information on energy analysis tools, datasets, free applications, and discussion forums
Smart Energy Analytics Campaign		An industry-sponsored effort to encourage the use of Energy Management and Information Systems (EMIS)
Efficiency.org	Open EE Meter	Open source code to "meter" energy savings with standardized, automated algorithms.
MEETS Coalition	Metered Energy Efficiency Transaction Structure	An M&V 2.0 "meter" by EnergyRM that is billed as capable of quantifying real-time savings with sufficient accuracy to enable large-scale, long-term deep-retrofit projects
American Council for an Energy-Efficient Economy (ACEEE)	M&V 2.0: Hype vs. Reality and Intelligent Efficiency	Evaluation of 21 commercial 2.0 software tools presented at the 2016 ACEEE Summer Study on Energy Efficiency in Buildings and review of Intelligent Efficiency: made possible information and communication technologies
Electric Power Research Institute (EPRI)	End-Use Energy Efficiency and Demand Response	EPRI's 2017 research plan
Carnegie Mellon University's Electricity Industry Center		A key research and advisory university laboratory
Dissertation Research by Sam Borgeson (2013)	Targeted Efficiency: Using Customer Meter Data to Improve Efficiency Program Outcomes."	A thesis dissertation that provides examples of the types of analysis and programs enabled by AMI data and related customer engagements
Lawrence Berkeley National Laboratory's Building Technology and Urban Systems Division	Application of automated measurement and verification to utility energy efficiency program data.	A comparison of traditional energy efficiency measurement and verification (M&V) techniques to automated whole-building M&V techniques based on smart meter data.

Organization	Key Project of the Group	Description of the Project
Natural Resources Defense Council and VEIC	Putting Your Money Where Your Meter Is: A Study of Pay-For-Performance Energy Efficiency Programs in the United States	Regulatory information and recommendations for AMI deployment
Consortium for Energy Efficiency (CEE)	Whole Building and Connected Home Committee Work	Initiatives that identify products/services and engage manufacturers and other stakeholders to discuss verifiable savings
M&V 2.0 Protocols and Standards		
US Department of Energy's Office of Energy Efficiency and Renewable Energy	Uniform Methods Project for Determining Energy Efficiency Program Savings	Comprehensive set of protocols from US DOE
Efficiency Valuation Organization	International Measurement & Verification Protocol (IPMVP)	Comprehensive set of protocols from international stakeholders
International Organization for Standardization (ISO)	ISO 50001 Energy Management	Underpins Strategic Energy Management (SEM)

APPENDIX 1: M&V 2.0 QUESTIONS TO SHARE

Below is a list of questions shared with participants during the VEIC-facilitated breakfast dialogue on M&V 2.0, held on February 8, 2018 at the Midwest Energy Solutions Conference in Chicago, IL. Take a moment to think these through and talk about the following topics with your colleagues.

- What are the services and organizational strengths you are currently focused on improving? Are there specific new technologies or approaches that you are considered adopting?
- Is there an opportunity to leverage your current customer engagement success elsewhere? What would you do the same, or differently?
- Discuss proof of concept opportunities that could help demonstrate data-value. How could you use this to start a positive feedback loop and build data access into your programs?
- Can you identify any internal or external activities that would bolster your data bank? Are there other factors that you are looking at addressing – such as reducing program costs?
- Turning customers back on: would offering your program in a more compelling/less cumbersome way (same thing different message/process) help?
- Are there any recurring topics in customer feedback channels that highlight general areas for improvement? High-bill alerts, customized savings recommendations, or something else?
- How do you receive/track/manage customer engagement and satisfaction and share information about a new program or customer-specific opportunity? How do you track these and do you wish you could track this is a different way?
- Do you feel in touch with your customers, or do you feel your service provider “gets your needs”? Are there specific markets that are challenging to reach (small-business, rural, low-income, or other?)
- Do you know what the major barriers to reaching these markets are or why it is hard to reach you? Is it all about customer engagement, finance, data, or something else?
- How are you currently using/seeing data for/in customer-facing reports, alerts, and other interfaces?
- How are you currently using your data to support program staff (or other internal experts) with reports, alerts, or other software/web interfaces? This could include both internal staff and infrastructure, as well as contractor/vendor/trade ally/partner systems and services.
- Are there specific emerging technologies that you want to support, perhaps driven by interest from customers or stakeholders? This could include mass-deployed systems such as smart grid or customer engagement portals, or it could be opt-in offerings such as smart thermostats, energy management systems, remote building audits, etc. If so, how are you identifying and evaluating these opportunities?

APPENDIX 2: M&V 2.0 GROUP ACTIVITY

TYPICAL GOALS OF A NO-DOZE EXERCISE

- Increases self-awareness of “challenges” and “aspirations”
- Informs others that there are many different approaches to addressing challenges or reaching goals
- Acknowledges each approach is equally valid and each can have its own set of challenges
- Appreciates different starting point/set of needs
- Values feedback and collaborative action

SIMILARITIES WITH WORKING THROUGH M&V 2.0

- Desire to increase awareness – given the sheer volume of information about M&V 2.0, it is a challenge to effectively determine what topics are of greatest interest or concern.
- There are different positions – this new territory of M&V 2.0 is not just for regulated programs. It is relevant for unregulated programs such as non-utility run programs, coops and municipalities and other stakeholders who have say in outcome, provide funding and accountability.
- There are different approaches – there is no one right way. Different utilities are responding and thinking about data streams and analytics tools in different ways.
- Feedback and collaboration is critical – the delivery of M&V 2.0 requires strong collaboration and support from internal actors (leadership, IT, billing, implementation, account managers) and across external stakeholders (contractors, regulators, customer advocates).

When and Why Should You Try?

There is still a considerable amount of misapprehension amongst utilities and other stakeholders on “what *M&V2.0* is” and “what *its* impact might be” and how then to best contribute to a conversation around what M&V 2.0 could mean for you.

While M&V 2.0 encompasses lots of nifty gadgets and apps that may be hard to resist, there is often a genuine need driving those impulsive desires, even if the requestor is not able to clearly articulate it at first.

The exercise of asking “why do we want to do that?” repeatedly can be helpful, moving from the attractive characteristics of a new shiny technology to the unmet needs of your customers. The goal of this exercise is not only to discover a clearer path through how M&V2.0 can help you, but also clarify the purpose of that venture, and what a successful outcome would look like for you. In the best-case scenario, the goal is defined first and then the approach can be designed as part of a larger strategy toward meeting that goal. But alignment with goals is an interactive exercise and it is important to understand the motivating factors behind the goals too.

Steps

Everyone in the room should stand and prepare to gather in groups defined by the answers to the questions below.

1. Create a visible line and divide your space into two areas. Define the line based on a motivating factor such as *“Customer Engagement/Response”*, and define either end of the line by stating something like: *“This far end represents serious problems! Your customers aren’t engaged at all, and the opposite end represents fantastic engagement.”*

Along the continuum, there could be *“poor customer engagement, trouble reaching the right customer or getting enough customers to respond to your offer, or getting interested customers to complete a project, or your finding it hard to figure out how to best engage with new program offerings.”*

2. Ask your group of participants to place themselves physically along the line that best reflects their experience.

TIP: Provide your group of participants with some possible perceived, answers (and if you know them well enough, provide advice on where you think they might lie on the line).

3. Define a second line, perpendicular to the first, based on a separate motivating factor such as "*Access to Customer Data, Data readiness & utilization",* and describe either end of the line by stating something like: "*This far end represents little data is being collected, limited access, and the opposite end represents you collect and can analyze significant amounts of data sets from customers and maybe even overlay other sources of data."*

Along this continuum, there could be "*limited awareness of what data you're collecting and what you're doing with it, or awareness of more granular data being available but not sure what to do with it (e.g. AMI)."*

Without moving from their relative positions on the first line, ask them to now position themselves sideways along this second line.

4. At this point your group is self-orientated into four segments. Start to walk through what each segment might represent (in terms of where people see the challenges they are addressing as well as where they would prefer to be) – some suggestions for talking points about the four quadrants are provided in the table below. Ask for individual input on why they see themselves where they are now.

5. Using the M&V 2.0 guidebook, identify the section that best frames your starting point, work through the check-lists and discover what strategy could provide the service, and support the functionality you need. Don't forget to leverage the additional resource support provided!

Bad data happens to good people (group 3, good engagement/bad data): If you are placing yourself here – you might feel good about customer engagement but don't have the access to the data you would like (maybe you are collecting it already and need to understand better what your IT/billing department is collecting and how it is being reported to your customers outside of the standard bill). Maybe you see an opportunity to use your customer's active engagement and request to try something new, but you need to figure out how to justify it? **Possible Goal:** Ensuring the outcomes from your data can effectively equate with savings in a reliable manner that shows your investment is cost-effective. Increasing your use and collection of data to further improve the delivery of a program. Increasing your savings by doing something a different way. **Questions:** Can you identify any internal or external activities that would bolster your data bank? Are there other factors that you are looking at addressing (reducing program costs)? **Options to consider:** Consumer Op-In or revised participation agreements; AMI and connected devises/sub metering.	**Envisioning the future (group 4, good data/good engagement):** If you are placing yourself here – you generally feel confident that your customer engagement strategy/feedback is good and you have a good sense of what data is available from your customers and potently other tools (submitters, etc.), how to collect it, how to use and interpret it to further encourage customer engagement and better determine impact (e.g. energy savings and maybe other NEBs that you can confidently figure out if this program approach is cost-effective). **Possible Goal:** Improving outcomes further (lowering costs, increasing accuracy, faster feedback, moving from pilot to program, adding tricks to your repertoire). **Questions:** Is there an opportunity to leverage your current customer engagement success elsewhere? What would you do the same/different? **Options to consider:** Changing metrics, planning for deeper, harder to reach savings opportunities, engaging new customer segments.
Catch-22 (group 1, poor engagement/poor data): If you are placing yourself here – you may feel like you are at a disadvantage. Hopefully not too many people are here. Maybe you recognize that the reason your customer engagement is low is because you do not actively collect or have access to data to help encourage or identify customers, or maybe because you do not actively run your program (you have 3rd party PA), so there is a knowledge/information gap about what is being collected and what responses are. **Possible Goal:** Increasing your collection of data to support customer engagement opportunities and demonstrate data-value. **Questions:** How could you use this to start a positive feedback loop and build data access into your programs? **Options to consider:** Try anything, for example, a small-scale pilot to get you moving forward.	**Gearing up (group 2, poor engagement/lots of data):** If you are placing yourself here – you may feel like you have lots of data (for example, something we've heard: we just rolled out AMI – now what do I do with all this information). Too much data can be paralyzing. Similarly, maybe you have just been told to overlay numerous different data sets (census, weather, grid, measure, SIC codes etc.), and you are not sure what or how to go about reading the patterns and what opportunities it may uncover? **Possible Goal:** Improving your use and analysis of data to improve the delivery of a program. **Questions:** Turning customers back on: would offering your program in a more compelling/less cumbersome way (same thing different message/process) help? **Options to consider:** Tweak your program with mid-term program adjustments, develop more compelling / motivating options for your customers (e.g., data-driven savings estimate).

Baseline efficiency: The assumed standard efficiency of equipment, absent an efficiency program.

Bluetooth: A wireless standard for low-power, short-range communications. Commonly included in computers and smart phones, this is sometimes used for "smart-home" devices to send data and receive commands.

Coincidence factor (CF): Coincidence factors represent the fraction of connected load expected to be coincident with a particular system peak period, on a diversified basis.

Commercial & Industrial: The market sector that includes measures that apply to any non-residential building types, which includes multifamily common areas and public housing.

Comparison group EM&V measures: Measures that determine program savings based on the differences in electricity consumption patterns between a comparison group, the program participants, not a deemed savings value. Comparison group approaches include randomized control trials (RCTs) and quasi-experimental methods using nonparticipants, and may involve simple differences or regression methods. Because the effects of implemented measures is reflected in the observed participant-comparison differences, separate verification is not required. These methods are generally used for planning purposes to estimate program-level savings, not facility- or project-level savings, and are therefore considered an evaluation method.

Connected load: The maximum wattage of the equipment, under normal operating conditions.

Continuous Energy Improvement (CEI): See Strategic Energy Management.

Custom measures: Measures or technologies that due to the complexity in the design and configuration of the particular measure in the energy efficiency project, a more comprehensive custom engineering algorithm and financial analysis may be used that more accurately characterize the energy efficiency savings within a project.

Deemed calculation: Agreed-to (stipulated) engineering algorithm(s) used to calculate the energy and/or demand savings associated with an installed efficiency measure or measures.

Deemed factor: Attributes of efficiency measures themselves or their impacts other than deemed variables and savings values. Examples are measure costs and effective useful life of measures.

Deemed savings method: The process by which predetermined estimates of energy and peak demand savings attributable to energy efficiency measures in a particular type of application or the engineering algorithms/equations or inputs are developed and adopted.

Deemed savings values: Documented, numerical values for specific efficiency measures such as *per-unit* savings that define the agreed-upon performance of an efficiency measure. Often subject to some form of implementation verification.

Deemed value: A value that has been assumed to be representative of the average condition of an input parameter.

Deemed variable: Values for independent (also known as explanatory) variables that determine the performance of an efficiency measure under different operating conditions, applications, climates, etc.

Default value: When a measure indicates that an input to a prescriptive saving algorithm may take on a range of values, an average value is also provided in many cases. This value is considered the default input to the algorithm, and should be used when the other alternatives listed in the measure are not applicable.

Demand savings: The reduction in electric (e.g., in units of kW) or fossil fuel (e.g., in units of Btu/hour) demand from the baseline to the demand associated with the higher-efficiency equipment or installation.

Demand side management (DSM): Strategies used to manage energy demand, including energy efficiency, load management, fuel substitution, and load building.

End-use category: A general term used to describe the categories of equipment that provide a service to an individual or building.

End-use energy efficiency: The use of less energy to provide the same or an improved level of service to the energy consumer; or, the use of less energy to perform the same function for the consumer.

EnergyPlus: A whole-building energy modeling software application that is maintained by DOE. It is used for simulating energy use in buildings. It includes heating, cooling, ventilation, lighting and even process loads.

Energy efficiency measure: At an end-use energy consumer facility, an installed piece of equipment or system; a strategy intended to affect consumer energy use behaviors; or modification of equipment, systems, or operations that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service.

Energy efficiency: For purposes of this report, "energy efficiency" means measures that reduce the amount of energy required to achieve a given end use. "Energy efficiency" also includes measures that reduce the total Btus of electricity and natural gas needed to meet the end use or uses.

Energy savings: Reduction in electricity use (e.g., in units of kWh) or in fossil fuel use (e.g., in units of Btu) as compared to a baseline consumption.

Equivalent Full Load Hours (EFLH): The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW) or therms.

Effective Useful Life (EUL): The effective useful life of a piece of equipment based on the manufacturers rating of how long the equipment will last. It is an estimate of the median number of years that the measures installed under a program are still in place and operable.

Evaluation, Measurement, and Verification (EM&V): The conduct of any of a wide range of assessment studies and other activities aimed at determining the effects of an efficiency program, project, or measure and understanding or documenting program, project, or measure performance, program or program-related markets and market operations, program-induced changes in energy efficiency markets, levels of demand or energy savings, or program cost-effectiveness.

Evaluation (synonym EM&V): In the energy efficiency arena, impact evaluation is an investigation process to determine energy or demand impacts achieved through the program activities, including but not limited to savings verification, measure research and program research.

High efficiency: General term for technologies and processes that require less energy, water, or other inputs to operate.

Intelligent Efficiency: A category of energy efficiency technology and practices that are characterized by their use of information and communication technologies (ICT). This includes building monitoring and controls for residential and commercial buildings, as well as process optimization in the industrial sector.

Interactive effects: Effects that an efficiency measure has on energy use or demand at a facility, but which are indirectly associated with the measure.

Interested stakeholders: Any party with technical knowledge of Energy Efficiency Program implementation savings calculations.

Lifetime: The number of years (or hours) that the new high efficiency equipment is expected to function. These are generally based on engineering lives, but sometimes adjusted based on expectations about frequency of removal, remodeling or demolition. Two important distinctions fall under this definition; Effective Useful Life (EUL) and Remaining Useful Life (RUL).

Load Factor (LF): The fraction of the full load (wattage) for which the equipment is typically run.

LoRa: Wireless communication technology optimized for long-range, low-power operation, but with very limited bandwidth. This makes it a good fit for battery-powered building monitoring.

Measure: An efficient technology or procedure that results in energy savings as compared to the baseline efficiency. There are three main measure types, prescriptive (partial and fully deemed), custom, and comparison group M&V measures.

Measure cost: The incremental cost (for time of sale measures) or full cost (both capital and labor for retrofit measures) of implementing the high efficiency equipment.

Measure description: A detailed description of the technology and the criteria it must meet to be eligible as an energy efficient measure.

Measure research: An evaluation process focused on providing better/more granular data to facilitate updating measure-specific input values or algorithms.

Measurement and Verification (M&V): A method through which energy or demand savings are determined by a combination of implementation verification, agreed to or deemed calculations and analytical methods, and/or measurements and stipulations of key independent variables.

Non-Intrusive Load Monitoring (NILM): A category of software (and sometimes associated hardware) technologies that are able to "disaggregate" individual end-use loads, or appliances, within a building while only monitoring energy use at the main power meter. This provides detailed monitoring of energy use at a much lower cost than installing separate energy meters on each appliance.

OpenStudio: A collection of software tools for creating, editing, and running EnergyPlus energy models. This open source software not only makes it easier to work with EnergyPlus models, it also provides a mechanism to automate model changes from other software and scripting languages.

OpenEEmeter: An open-source software library for automating energy efficiency savings calculations, particularly weather-modeled baseline estimation.

Operating Hours: The annual number of hours that equipment is expected to operate.

Operation and Maintenance (O&M) Cost Adjustments: The dollar impact resulting from differences between baseline and efficient case Operation and Maintenance costs.

Partially deemed measures: Measures whose energy savings algorithms are deemed in the MO-TRM V.1.0, with input values that may be selected to some degree by the program administrator, typically based on a customer-specific input.

Prescriptive measures: Measures or technologies that are offered through a standard (in contrast to custom) program, for which partially or fully deemed input values are applicable.

Program: The mode of delivering a particular measure or set of measures to customers (e.g. direct install).

Program administrator: An entity selected by a regulatory or other government organization to contract for and administer an energy efficiency portfolio within a specific geographic region and/or market. Typical administrators are publicly owned utilities, investor-owned utilities selected by a public service commission, or a non-profit or state government agency, as determined by legislation.

Program implementer: An entity selected and contracted with or qualified by a program administrator to provide products and services to consumers either directly or indirectly.

Program research: An evaluation process that takes an alternative look into achieved program level savings across multiple measures. May not be specific enough to inform future program, TRM, or EM&V updates. Ex. Program billing analysis.

Residential: The market sector that includes measures that apply only to detached, residential buildings, duplexes, and applicable multifamily units.

Savings verification: An evaluation process that independently verifies program savings achieved through prescriptive measures.

Strategic Energy Management (SEM): A holistic approach to managing energy use by focusing on the creation of a culture of continuous energy improvement (CEI) across an organization to help improve productivity, quality and operations for commercial and industrial customers. SEM emphasizes the impact of energy consumption through behavioral and operational change and is often implemented through a cohort approach that encourages peer-learning alongside other CEI initiatives such as, ISO, Kaizen, and Six Sigma.

Technical Reference Manual (TRM): A document that consists of a set of standard methodologies and inputs for calculating the savings impacts and cost-effectiveness of prescriptive energy efficiency improvements offered through demand-side management programs.

Zigbee: Wireless communication technology for short- to mid-range low-power operation, sometimes used in smart meters and communicating, or "smart" appliances, or other IoT devices.