Impact Evaluation Research Design in a Post TRM World

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ABSTRACT

Historically, impact evaluations of energy-efficiency programs have aimed to verify *ex ante* (expected or claimed) energy savings. Impact evaluations typically involve either accepting the established *ex ante* savings methodology of the sponsoring utility and/or third party implementer and validating its various parameters, or calculating the savings based on an alternative method altogether. For example, a lighting program may be evaluated by verifying installation and full-load hours or by conducting a billing analysis to measure savings.

Increasingly, Technical Reference Manuals (TRMs) are being adopted in various states. TRMs are developed for a variety of reasons and are used in different ways. In California, for example, the database for energy-efficiency resources is primarily used to inform program design. In the Northwest, the Deemed Measure Database and the Planning, Tracking, and Reporting database—which were developed by the Regional Technical Forum, a special advisory group to the Northwest Power and Conservation Planning Council—establish saving values that form the basis for verifying saving targets. In Michigan and Pennsylvania, the TRM specifies the basis for determining *ex ante* savings claimed by utilities. For some measures, the Pennsylvania TRM specifies fully-deemed savings; however for most measures, it specifies the algorithm with some stipulated parameters. Several TRMs offer guidance on calculating savings for custom measures.

This proliferation of TRMs, particularly in states where they are the source for deemed and partially-deemed savings, will have a transformative effect on how impact evaluations are conducted, changing the focus of impact evaluations from an independent measurement and method of determining savings to a review of TRM calculations and verification of measure installations.

This paper catalogues TRMs in various states and describes their features, similarities, and how they are being used. The paper focuses on Pennsylvania as a case study to point out the practical implications of TRMs for impact evaluations. This paper does not analyze TRMs with respect to the accuracy or consistency of their methods; rather, it explores how TRMs affect the evaluation practice.

Introduction

A Technical Reference Manual (TRM) is a standardized source of technical specifications, saving estimates, or calculation algorithms, and in a few cases includes per-unit costs of energy-efficiency measures and practices. TRMs are generally approved for use by regulators in the jurisdictions where they are used. A TRM may be in the form of a document or an electronic database. The TRMs are intended to provide consistency (within the jurisdiction) of the methods and assumptions used to calculate and report energy savings for specific measures.

TRMs serve two primary purposes: to provide *ex ante* and/or *ex post* savings. *Ex ante* estimates are used to provide preliminary estimates of expected savings for planning purposes or to form the basis for local utilities' claimed savings. *Ex post* estimates are used to as the verified measure-level savings for the program.

In March 2011, 21 states and one district had TRMs. These included 15 individual state TRMs, two regional TRMs, and one national database of standard measures and deemed savings. The Northwest's Planning, Tracking, and Reporting (PTR) database is used in Idaho, Montana, Oregon, and Washington. The Mid-Atlantic TRM (often referenced as the NEEP TRM) is used in Delaware, Maryland, and the District of Columbia. The 15 state resources reflect smaller areas with generally less diversity in climate, baselines, and structural characteristics.

The Beginnings

Two significant efforts developing measures databases contributed to the evolution and propagation of the current TRMs. Both had origins in the 1990s, preceded by legislation focused on energy efficiency and conservation. One of these measures databases was developed by the Regional Technical Forum (RTF). The second is the Database for Energy-Efficiency Resources (DEER), sponsored by the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC). Extensive research and field-based studies underpin both references.

Regional Technical Forum

The Northwest Power Planning Council (Council) formed the RTF in 1999 as a special advisory committee. In addition to standardizing protocols, the RTF is responsible for making recommendations to Bonneville *"…of eligible conservation measures and programs, the estimated savings associated with those measures and programs, and the estimated regional power system value associated with those savings.*" Four savings estimation methods were defined by the RTF: deemed unit energy savings, standard protocol, custom protocol, and program impact evaluation. The RTF intends for each method to produce savings estimates of comparable reliability, sufficient to serve the needs of long-term regional energy planning and resource acquisition. These methods also support regulatory processes related to the adoption and planning of energy-efficiency initiatives (Council, 2010; SBW 2011).

Database for Energy Efficient Resources (DEER)

The first DEER update phase began in 2003, and the second phase began in late 2004. Within the two phases, non-weather sensitive measure analyses and results were enhanced and expanded, savings estimates for weather sensitive measures were created, and the DEER Website was fully populated with both weather sensitive and non-weather sensitive data and was made available to the public in August 2005. The measure cost dataset was updated at the same time. The 2005 DEER included at least 145 broad measure categories, encompassing over 400 energy-efficiency measures and permutations of the measure savings estimates for different California climate zones, building types, and building vintages. The 2005 DEER database is superseded by the 2008 DEER update, developed by the CPUC with funding provided by California ratepayers. The 2008 DEER database includes fewer broad measure categories, for a total of 31. Savings estimates were developed using engineering calculations, simulation models, and/or field and laboratory measurements.

A central purpose of DEER has been to maximize the accuracy and consistency of per unit, *ex ante* measure data used by the CPUC and utilities in program planning, filings, tracking systems, cost-effectiveness analyses, and energy-efficiency forecasting. DEER has also been used to conduct quality control analyses of *ex ante* data provided by third-party implementers.

The Next Generation

Several recent studies have been conducted to improve understanding of how energy-efficiency measure energy savings are determined. These studies examined evaluation, measurement, and verification (EM&V) practices and methods currently in practice, and the role of EM&V protocols and TRMs or standard energy-efficiency measure databases. These studies identified gaps and needs, and often recommended the development and use of comprehensive guidelines to increase consistency in evaluation methods across jurisdictions and regions (Schiller, 2007; Messenger et al, 2010; KEMA, 2010).

The Cadmus Group researched regional and state TRMs in use as of March 2011 and identified 21 states and regions using TRMs and measure databases, shown in Table 1. Regions include those within the Northwest's RTF database and NEEP's TRM. Most were developed in answer to regulatory requirements. Table 1 shows the administrator and of the TRMs as defined in each document. Each TRM states whether it was developed for planning purposes (*ex ante* estimates of savings) or for evaluation (*ex post* evaluated savings). Some TRMs state they are for program and efficiency investment planning and regulatory research (e.g., California, Michigan, and Ohio). Other TRMs state they instruct evaluation by providing standard approaches to measuring program energy savings (e.g., Arkansas, New Jersey, and New York). Whether used for planning or evaluation, the TRMs are intended to provide transparency into the process of measuring energy savings.

The number of measures included in each TRM is shown in the table. Measure counts represent measure categories rather than unique permutations (e.g., a measure represented by savings across multiple building types or vintages is counted as one measure). In addition, commercial lighting as a whole is considered one measure.

Table 1. Current Regional and State TRMs and Reference Documents

Territory	Resource Name	Administrator	Purpose as Stated in TRM Reference Document	Total Measure Count
Regional PNW	Regional Technical Forum Deemed Measures (2011 download)	NW RTF	To verify and evaluate conservation savings	62
Regional Mid-Atlantic	Mid-Atlantic Technical Reference Manual (2010)	NEEP	To verify and evaluate conservation savings	32
Arkansas	Arkansas Deemed Savings Quick Start Programs (2007)	Arkansas Public Service Commission	To calculate savings through Arkansas Deemed Savings Quick Start Programs	51
California	Database for Energy Efficient Resources (2005 & 2008)	CPUC	Program planning and regulatory research and evaluation efforts	31
Colorado	Colorado 2009-2010 DSM Plan Appendix E - Technical Reference Manual	Xcel Energy	n/a	79
Connecticut	CL&P and UI Program Savings Documentation	CL&P and UI	Detailed, comprehensive documentation of all claimed resource costs and savings corresponding to individual C&LM technologies	93

Territory	Resource Name	Administrator	Purpose as Stated in TRM Reference Document	Total Measure Count
Hawaii	Hawaii Energy Efficiency Program Technical Reference Manual	Hawaii Energy (KEMA)	For estimating energy and peak impacts from measures and projects that receive cash incentives from the Hawaii Energy Efficiency Program	16
Maine	Efficiency Maine Technical Reference Manual	Efficiency Maine	For estimating energy and peak impacts from measures and projects that receive cash incentives from the Efficiency Maine Business Program	30
Massachusetts	Massachusetts Statewide Technical Reference Manual for Estimating Savings from Energy Efficiency Measures (2011)	DOER	To show how the energy-efficiency program administrators consistently, reliably, and transparently calculate savings from the installation of efficient equipment	110
Michigan	Michigan Energy Measures Database (MEMD) (2009)	Michigan Public Service Commission	For development of initial energy-efficiency savings calculations and potential savings for energy-efficiency programs	119
New Jersey	New Jersey Clean Energy Program Protocols to Measure Resource Savings	NJ Clean Energy Program	For the purpose of determining energy and resource savings for technologies and measures supported by New Jersey's Clean Energy Program	62
New York	New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (2010)	NY Dept of Public Service	To provide a standardized, fair, and transparent approach for measuring program energy savings	88
Ohio	Ohio TRM (2011 download)	Ohio PUC	To serve as a tool to support planning efficiency investments and in meeting efficiency goals	107
Pennsylvania	Pennsylvania PUC Technical Reference Manual (2011)	Pennsylvania Public Utility Commission	Estimating annual electric energy savings and coincident peak demand reductions	73
Texas	Deemed Savings, Installation & Efficiency Standards	Public Utility Commission of Texas	To document all of the approved energy and peak demand deemed savings values	23
Vermont	Efficiency Vermont Technical Reference User Manual (2010)	VEIC	For estimating energy and peak impacts from measures and projects promoted by Efficiency Vermont's energy-efficiency programs	108
Wisconsin	Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0 (2010)	Public Service Commission of Wisconsin	To show how savings estimates were determined for each deemed measure	54

Other available resources provide detailed information on measure costs and savings. While not discussed in this paper, these resources include: the National Renewable Energy Laboratory (NREL) National Residential Efficiency Measures Database; conservation potential assessment (CPA) reports, including the Council's Sixth Power Plan. In addition, the National Laboratory Collaborative on Building Technologies (NLCBT), recently launched by the Department of Energy (DOE), is developing the National Energy Performance Data Warehouse. Finally, the ENERGY STAR® calculators, available through the ENERGY STAR® program, contain measure-specific savings calculators in Microsoft Excel®.

An overriding question is to determine why TRMs have proliferated. The measures within most TRMs are essentially the same, so there likely have been redundant expenses associated with setting up separate TRMs around essentially the same measures. Most TRMs have their genesis in significantly ramped up state efficiency goals and the corresponding need for a state-wide or region-wide management of potentially significant expenditures. While this effort to develop state-specific TRMs may appear technically redundant, and while one TRM may contradict technical particulars in other TRMs, area-specific TRMs are needed due to regional variations in factors affecting measure savings (such as climate) and possible other factors like labor costs and local conditions that lend certain measures more or less applicable. It appears, however, that it is not the technical aspects that underlie the TRM phenomenon of growth. The TRM is evidence of a region or state taking responsibility for its efficiency goals. The TRMs facilitate calculation and reporting of savings, standardization of the process, and creation of a more transparent and predictable calculation of savings for utilities investing in energy efficiency.

One State's Experience: Pennsylvania's Act 129 and their TRM

Pennsylvania's Act 129 of 2008 charged electric distribution companies (EDCs) with at least 100,000 customers to develop and implement an energy-efficiency and conservation plan to reduce consumption by at least 1 percent by May 2011 and 3 percent by May 2013. In addition, the Act sets peak demand reduction targets of at least 4.5 percent of the top 100 highest load hours for the EDC. The Act requires EDCs to conduct impact analyses of their programs and report the results 45 days after the close of each quarter. Recently, the deadline for the final annual report of verified savings was extended to six months after the year closes.

The Public Utilities Commission (PUC) oversees a Statewide Evaluator (SWE), charged with evaluating the utilities' energy-efficiency and conservation programs. Each EDC contracted with an independent evaluator. Figure 1 shows the relationships and flow of information from the SWE to the regulatory documents including the Audit Plan, the TRM, and Guidance Memos. These documents determine the form of the EDC's program design, evaluation plans, evaluation activities, and verified savings.

The TRM developed for Act 129 provides savings calculation methods to determine annual energy savings for a localizable list of energy-efficiency technologies and measures. The savings calculation method specified in the TRM influences program design details such as measure eligibility requirements, rebate application forms, the amount and type of information that must be obtained from customers, and tracking systems. The initial 2009 TRM was derived from the New Jersey TRM and compiled by the PUC. This initial TRM was in effect during the program and portfolio planning phase. However, because of limited time between the Act 129 legislation and the date that energy efficiency plans were due, this first version of the TRM was significantly incomplete. Subsequent versions added measures and changed other measures. Most revisions and additions were discussed and/or developed within a technical working group comprised of members of each utility, their evaluators, PUC staff, and the statewide evaluator. Some of the changes were significant, decreased savings, and added complexity to program design and implementation details.

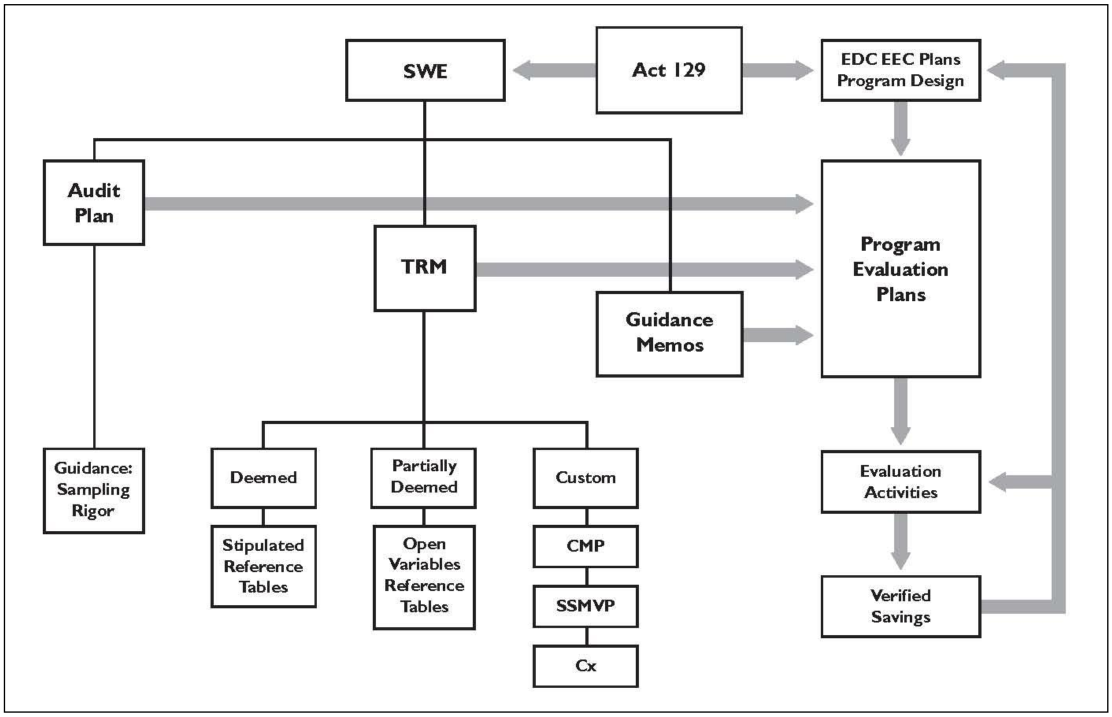

Figure 1. PA Act 129 Guidance Documents and Information Flow

While standardizing how savings are calculated and reported makes the verification process simpler, it also poses a number of challenges. It is sometimes difficult to obtain accurate information from customers so the utility and evaluator can determine *ex ante* savings in accordance with the TRM, particularly for measures with open variable algorithms in the TRM. For example, computing savings for commercial lighting projects requires detailed information about pre- and post-installation conditions for lighting retrofits such as ballast type, bulb type, wattage, building and space type, and lighting controls. Collecting data from customers is difficult when they don't know what SEER and capacity means, let alone know that they have installed an air source heat pump, air conditioner, or a ductless heat pump. In addition, getting five different Electric Distribution Companies (EDCs) regulated by this PUC, five different independent evaluators, the PUC, and the SWE to coordinate and agree in a timely manner is a challenge, especially given time constraints and reporting deadlines.

How a TRM Affects the Evaluation

Pennsylvania EDCs have made substantial investments in program implementation and evaluation to meet the Act 129 reporting requirements. These requirements often demand a quick turnaround in reporting the achieved quarterly and annual energy savings. At the same time utilities are determining savings achieved in the past quarter and year, they are also planning for the next program year or next program cycle more than one year in advance.

Because of this timing, evaluations must be conducted in a very short time frame to provide rapid feedback, leaving little time to collect post-installation usage data and analyze the change in consumption from the original condition. In the current evaluation climate, utilities often cannot wait for one year of post-installation consumption data and a billing analysis to determine what happened at the meter. While the planning urgency has increased, the underlying physics have not changed; it still takes a finite time, often a year, to collect accurate measurements.

Utilities Use the Planning Estimates to Create Portfolios

Penalties for not meeting the mandated Act 129 saving targets are significant, set at $1 million with a maximum of $20 million. With these significant penalties, tight deadlines, and limited budgets, utilities need protocols, guidelines, and other means to reduce uncertainty so that they can design their programs to provide fairly predictable savings (i.e., per-measure savings used in planning assumptions must be reasonable predictors of the actual per measure *ex post* savings).

The Method Specified in the TRM Influences Program Design and Implementation Detail

From the implementer's perspective, utilities are monitoring reported savings in "real time." Having a TRM reduces the risk that the implementer will see significant differences between ongoing *ex ante* reported savings and the *ex post* verified savings determined six months or more after the close of a program year.

Utilities plan to claim savings as stipulated in the TRM and design their programs and portfolios around these anticipated (*ex ante*) savings. The TRM also defines the measure eligibility requirements, the type of information to obtain from customers on the rebate forms, the type of information that needs to be verified, and how to design the data tracking systems to properly document installed measures and determine their savings.

Consider just the rebate application form, for example: if a measure is partially deemed with open variables, the rebate form must be designed to collect information the EDC requires to determine *ex ante* savings and the information the evaluator require to determine *ex post* savings. For example, a heat pump's capacity, SEER, and installation location (dictating climate and ultimately effective full load hours (EFLH)) are open variables in the savings algorithm, so the data must be collected from the customer via the application or supporting documentation. If not collected on the forms, the evaluator must collect the data via site visits and additional research (equipment make and model look-ups, for example).

Making changes to the TRM can create uncertainty and complexity. It requires changes to planning savings, could change data collected, rebate forms, and the data tracking system.

The Expectation is that the Savings Referenced in the TRM can be Claimed as Achieved

Utilities may expect to make little or no adjustment to the *ex ante* savings, and only expect to count the number of measures and multiply by the TRM-stipulated savings. Evaluators plan their activities around the TRM specifications and associated directives. Stipulated savings may or may not include installation rates (e.g., some CFL savings embed an installation rate, other measures do not). Unless an error is found in the governing algorithm, evaluators adjust the fully deemed savings only for verified installation rates. They may adjust partially-stipulated savings requiring inputs from open variables for additional factors when savings are verified.

Measures can also be expected to be added to a TRM over time, but deemed measure-level savings can also change during annual updates or periodic reviews. When changes are made to savings already stipulated, or to the savings algorithm and input data that must be collected, there are far reaching consequences. For example, reducing savings by 40 percent mid-cycle (two years into a four year program cycle) for a popular measure may cause the program, and perhaps the portfolio, to not meet targets as planned—requiring redesign. Changes to a savings algorithm, measure eligibility requirements, or baseline conditions affect various program implementation requirements, such as spending additional funds to communicate the change, changing the eligibility requirements, redesigning the application form to collect additional or different information, adding fields to a data tracking system already in use, and changing and reprinting promotional materials. Practicality and flexibility suggests restricting changes to the commencement of a new program cycle so that utilities can pursue their targets.

TRMs Change the Focus of an Evaluation

Ex ante savings are the program implementer's best estimate of savings the efficiency measure is expected to produce under ideal circumstances. Traditionally, impact evaluations have, by design, employed methods to determine energy savings and demand reductions independent of the program administrator and implementer. In typical impact evaluations, reviews are conducted on the algorithms, inputs, and assumptions used to compute *ex ante* savings. Evaluators should conduct this review as routine procedure, but may not review if the TRM uses previously vetted and fully stipulated savings. This may be particularly true where the utility expects to use the TRM values for *ex ante* and *ex post* savings. In this case, using the TRM changes the evaluation focus to verification of the number of measures installed and the input variables of the stipulated savings algorithms. Using the TRM for *ex ant*e values shifts the activities from *ex post* to *ex ante* related activities.

Data collection required to assess the change in energy use resulting from the installed measure can take the form of pre- and post-installation metering, or statistical analysis of consumption histories. Collecting accurate measurements and updating the TRM values on a regular basis should be built into the evaluation process. This requires planning up front, since it takes time and evaluation budget to complete these analyses. A feedback loop from evaluation to updating the TRM is recommended.

Do Measure and Program Savings add up to Portfolio Savings?

There are many technical reasons, some enumerated here, why TRM derived savings may not be accurate, but the key question is whether they are *reasonable and usable for planning and evaluation.*

Differences in TRMs. One could argue that savings claimed using a TRM accurately reflect the achieved savings only if the individual measure's deemed or partially deemed savings are accurate. However, recent Cadmus research found that savings algorithms across state TRMs sometimes present circular references with no true underlying data source. For other measures, no references are cited for some parameters in the savings algorithms. In other cases there is wide variation in baseline assumptions and inputs, as well as differences in the savings algorithms themselves that lead to different savings estimates for the same measure.

Stacking effect. When savings for individual measures are stipulated, the evaluator no longer independently examines the whole building to assess building-level changes in consumption. Aggregate savings are calculated as the simple sum of individual measure savings, ignoring interactive and measure stacking effects which can lead to overstated savings and double-counting. Interactive effects of existing equipment and the installed measures, and/or of multiple technologies installed, are not typically considered since the savings derived for the TRM are only for one installed measure/technology. Evaluators can verify the number of items installed, but may be missing the measurement portion of their typical measurement and verification (M&V) procedures. The California PUC is currently examining the effect that stacking measure-level savings has on portfolio-level savings.

Loss of precision. Not every energy-efficiency measure can have stipulated or partially stipulated savings. Since TRM reference tables used to compute savings typically do not include all possible permutations, the best fit is used and precision is lost. For example, weather sensitive measures may have assigned savings according to reference by city. For example, in Pennsylvania, air conditioners and heat pumps are mapped by zip code to one of seven cities (four in PPL Electric's service territory), using a best fit approach to estimate savings (such as EFLH) for the climate zone where the measure was installed. Likewise, there are many instances in commercial lighting where the pre- and/or post-installation fixture/lamp/control combinations are not included in the TRM reference tables.

Less rigor. Used for planning, the TRM savings provide a starting place. Once the measures are included in the TRM and used as the *ex post* evaluated savings, evaluators' efforts are less rigorous. That is, accepting the TRM *ex ante* savings as a substitute for *ex post* savings diminishes the reliability of evaluated savings; the evaluation can become an accounting exercise where measures are counted and savings per measure are simply multiplied by the number of measures. If deemed savings apply to evaluators' *ex post* savings as well, there is no point in collecting updated numbers—and the old savings value lives on. Once accepted and used as *ex post* savings, a source of the data that could be used to update savings is eliminated. On average the values may be fairly accurate, but evaluators will be unable to tell how or if the numbers are skewed without frequent reviews and updates.

Should the Same Estimates be Used for *Ex Ante* Saving and *Ex Post S*aving Estimates?

The evaluation of energy-efficiency programs and the measurement of savings are conducted on the basis of average values as a matter of essential practicality. The use of a TRM value in the *ex post* context along with actual measure counts goes a significant way toward estimating the real savings, because at least the level of program activity is empirically derived. The underlying logic of the proliferating TRMs is that such *ex post* savings estimates are sufficient to support energy-efficiency policy and are accurate enough to serve as due diligence with respect to their cost-effectiveness. This process may work, if the TRM is periodically updated by targeted field research.

In theory, an impact evaluation unique to the program and technology is the best way to establish savings, but it is expensive and the results may require more than one year to develop. However, in practice impact evaluations are almost always hampered by lack of data, poor field timing, equipment malfunctions, protocol errors, measurement uncertainty, and other factors. Because of this, the theoretical ideal is hardly realized. In a sense, every impact evaluation measurement is research that requires broad and practiced experience. It is not reasonable to expect impact evaluations to be conducted on all or most programs with uniformly accurate results. The TRM approach could potentially improve the practice of impact evaluation by focusing resources on sufficient and properly executed impact measurements using data sets that might be shared among utilities or across TRMs. This could lead to the emergence of impact measurement specialists that are associated with different types of measures, and that have deeper and more practiced skills than are seen in current practice.

The long-term maintenance of a TRM is expensive, as evidenced by the experience of legacy databases such as the DEER the RTF. The RTF has an annual budget of approximately $1.3 million to update and maintain the TRM, with additional utility contributions. It is not probable that other TRMs comprised of essentially the same measures will have the funding to develop to the same extent. Future TRMs may continue to evolve down one of two paths: (1) reference databases compiled from other sources and adapted to the region; and (2) databases that are based on more active research, updated regularly, and where data and analyses are provided to other entities for their use and adaptation.

Moving Forward

TRMs in effect today are firmly planted as the new generation of tools for planning and evaluation. Experience using the tools and witnessing their evolution point to several recommendations, discussed above and summarized here.

- When introduced for the first time in a new jurisdiction, the TRM should be robust, well defined, and tailored to the location and circumstances.
- Examine the effect that stacking measure-level savings has on program-level savings. Accounting for interactive effects will increase the accuracy of savings estimates.
- Conduct reviews and regular updates of the TRMs to ensure the savings are still reasonably accurate. Involve the utilities, evaluators, regulators, and respective experts to ensure the savings calculations are fully vetted and appropriate for the technology and region.
- Update the TRM with cost-effective field research. Focus impact evaluation resources on sufficient, properly executed, and targeted field-based measurements. It may be possible to share data sets among utilities or across TRMs.
- Coordinate major changes to TRM savings values with the commencement of every new program cycle.

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