Protocols for Evaluating Energy Efficiency – Both Sides of the Atlantic

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Abstract

Having standard protocols for measurement & verification (M&V) and additionality, or net effects, of energy efficiency impacts is critical to maintaining confidence in utility- or government-sponsored programs, in energy service companies, and in energy efficiency obligations/white certificate schemes. A number of protocols have been developed on both sides of the Atlantic, including the following:

- International Protocols
  - International Performance Measurement and Verification Protocols
  - Tool for the Demonstration and Assessment of Additionality
  - Monitoring and Reporting Regulation for the European Emissions Trading Scheme
  - Common Methods and Principles for Calculating the Impact of Energy Efficiency Obligations Schemes in Directive 2012/27/European Union
  - Measuring and Reporting Energy Savings for the Energy Services Directive 2006/32/EC
- Protocols used in the European Energy Efficiency Obligation Schemes
  - Italy
  - U.K.
  - France
  - Denmark
- U.S. Protocols
  - Uniform Method Project Protocols
  - Model Energy Efficiency Program Impact Evaluation Guide
  - California Evaluation Framework
  - California Evaluation Protocols
  - American Society of Heating, Refrigerating, and Air-Conditioning Engineers Guideline 14, Measuring Energy and Demand Savings
  - Regional Technical Forum
  - California Standard Practice Manual

These protocols have many similarities, but also significant differences in terms of allowed approaches as well as terms used. Harmonizing these protocols will facilitate international trade in the energy efficiency industry and the development of international agreements for climate change mitigation. This paper will present a summary of the uses of the protocols, the major protocols in use, key distinctions, and recommendations for harmonization.

Introduction

Evaluation protocols provide minimum requirements and/or standard approaches for determining savings realized by energy efficiency programs and projects. It is critical to maintaining confidence in utility- or government-sponsored programs, in energy service companies, and in energy efficiency obligations such as white certificate schemes that there be standard protocols for measurement and verification (M&V) and additionality, or net-to-gross (NTG) effects, of energy efficiency impacts

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many similarities, but also significant differences in terms of allowed approaches as well as terms used. Harmonizing these protocols will facilitate international trade in the energy efficiency industry and support the development of international agreements for climate change mitigation. This paper presents a summary of the uses of the protocols, the major protocols in use, key distinctions, and recommendations for harmonization.

Several terms are key to understanding various protocols and their differences:

- **Program evaluation:** Systematic, objective studies that are conducted either periodically or on an ad hoc basis, to assess how well a program is achieving its intended goals
- **M&V:** Estimation of electrical energy, electrical demand, and fuel energy saved due to a measure or a project based on field measurements
- **Impact evaluation:** Estimation of the amount of electrical energy, electrical demand, and fuel energy saved due to a program
- **Process evaluation:** Examination of ways to improve program marketing and implementation.
- **Market evaluation:** Estimation of effects of programs on the market
- **NTG:** This term is used primarily in North America. It refers to the proportion of outcomes that are attributable to the program rather than other influences, such as market drivers or other programs. Net-to-gross includes free ridership (savings that would have occurred in the absence of the program) and spillover—(savings attributable to program influences that occur outside of the program). This concept is similar to additionality.
- **Additionality:** This term is used primarily in the context of the Kyoto Protocol. It refers to emissions reductions savings that are additional to any that would have occurred in the absence of certified project activity. The concept is similar to NTG.
- **Deemed savings:** Estimated (or deemed) savings are typically set per efficiency measure/technology and unit of application (e.g., savings per furnace per household), which is derived from historical evaluations, usually used with programs targeting simpler efficiency measures with well–known and consistent performance characteristics.
- **Ex ante savings:** Savings estimated before EE measure implementation
- **Ex post savings:** Savings estimated after implementation. More expensive but more accurate than ex ante savings.

International Protocols

International Performance Measurement and Verification Protocols (IPMVP)

This protocol (Efficiency Valuation Organization 2012) was developed with participation from organizations from 15 countries in Europe, North America, Asia, and South America over 20 years. It focuses on M&V, not program evaluation. As such, it does not address NTG or additionality at all. The protocol emphasizes ex post approaches. A report on guidelines for the monitoring, evaluation, reporting, verification, and certification of energy efficiency projects for climate change mitigation (Vine 1999) listed IPMVP as the preferred choice for monitoring and evaluating energy efficiency projects for climate change mitigation. This protocol identifies four options for M&V, which are frequently listed by other protocols.

Option A. Partially Measured Retrofit Isolation. Savings are determined by partial field measurement of the energy use of the system(s) to which an energy conservation measure (ECM) was applied, separate from the energy use of the rest of the facility. Measurements may be either short term or continuous.

Option B. Retrofit Isolation. Savings are determined by field measurement of the energy

use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Savings are determined by field measurement of all key performance parameters which define the energy use of the ECM-affected system. No stipulations are allowed; thus, full measurement is required. Short-term or continuous measurements are taken throughout the post-retrofit period, and preferably before the retrofit as well to establish baseline energy consumption or demand.

Option C. Whole Facility. Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.

Option D. Calibrated Simulation. Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option requires considerable skill in calibrated simulation.

Tool for the Demonstration and Assessment of Additionality

This document (United Nations Framework Convention on Climate Change [UNFCCC] 2011) provides a general framework for demonstrating and assessing additionality and is applicable to a wide range of project types. The framework employs a series of steps:

1. Demonstrating whether the proposed project activity is the first of its kind
2. Identifying alternatives to the project activity
3. Performing investment analysis to determine that the proposed project activity is either
    a. not the most economically or financially attractive, or
    b. not economically or financially feasible
4. Performing barriers analysis
5. Performing common practice analysis

The tool is focused specifically on additionality and projects. It does not address gross impact. This is one of the few documents addressing cost issues.

Measuring and Reporting Energy Savings for the Energy Services Directive

The Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services (EMEEES) project (Wuppertal Institute 2009) that ran between 2006 and 2009 had as a purpose to look into the best evaluation methods for energy efficiency programs in the European Union, in light of the Directive 2006/32/EC.

The project developed several methodologies that can broadly be categorized as “bottom-up” and “top-down”, with each methodology tailored to a specific end use (e.g., boilers, lighting, and insulation) and sector (residential, tertiary, industrial, and transport).

For bottom-up approaches, the developed methodologies are combinations of the following calculation techniques:

- Direct measurement
- Analysis of energy bills
- Enhanced engineering estimates
- Deemed estimate
- Ex post estimate

The project’s proposed methodologies include the use of NTG correction factors to account for double-counting, free-riders, and additionality. To determine the correction factors, the evaluator can use the following:

- Surveys of participants
- Monitoring of participants and end-use actions for different measures

For top-down approaches, the overall energy savings are estimated using regression analysis based on data from a period that precedes the implementation of the measure being evaluated, which would be able to account for the impact of various external factors, such as energy prices and economic growth.

The EMEEES project concluded that the selection between bottom-up and top-down methods depends on the type of measure evaluated and also the availability of data. There is also a trade-off between accuracy and administrative effort between the two methodologies.

Common Methods and Principles for Calculating the Impact of Energy Efficiency Obligations Schemes

The EU Directive on energy efficiency of 2012 (Directive 2012/27/EU of the European Union on energy efficiency, Annex V) includes a requirement for Member States to develop energy efficiency obligations for suppliers and distributors that would lead to annual energy savings of 1.5 percent of their total energy sales between 2014 and 2020 (Article 7). A common framework to measure the impact of obligation schemes and equivalent measures is outlined in Annex V of the Directive.

Specifically, four measurements options are identified:

1. **Deemed savings.** Ex ante reference to predetermined savings

2. **Metered savings.** Ex post measurement based on the recording of actual reduction in energy use

3. **Scaled savings.** This method is to be used in large installations and allows the use of engineering estimates for the savings.

4. **Surveyed savings.** This method is used for measures that impact consumer behavior, such as advice, information campaigns, and labeling.

These options are the ones generally being used in the biggest energy efficiency obligation schemes in Europe today (see below).

There is no guidance in the Directive for other aspects of the schemes, such as approaches to verification, additionality and materiality.

European Energy Efficiency Obligation Schemes

One common energy efficiency policy tool in Europe in the past couple of decades has been Energy Efficiency Obligation (EEO) schemes, also known as Energy Saving Obligations, Utility Obligations, Energy Efficiency Resource Standards or White Certificates Programs. These programs consist of some energy-saving obligation imposed on either the suppliers or distributors, often coupled with some trading option.

Overall, in the European EEO programs, the use of deemed measures that have predefined, ex ante savings per installation is the dominant measurement methodology. In some of the Member States (Italy, France, and Denmark), there is also the option of using alternate methodologies for measurement of energy savings, but they have not caught on as much with the exception of the Danish program.

Since the majority of the European programs rely substantially on the use of deemed measure savings for the reporting of energy savings, the dominant methodology for accounting additionality

is the use of pre-determined net-to-gross coefficients upfront when the portfolio of measures is designed. In other words, the savings reported by the participants in these programs are net savings, as additionality has been addressed ex-ante on the program-level. (De Lovinfosse et al., 2012) In the case of building retrofit measures, the baseline is usually the building code or the existing state of the building, whereas for appliances, the baseline is calculated based on the average energy consumption of similar appliances in the regional market (sometimes weighted across sales).

In the case of measures that are not in the lists of deemed measures, the program operator needs to develop a baseline and demonstrate the level of additional energy savings to the program administrator.

In the majority of the European programs, verification is conducted in the form of sample checks either in a predetermined rate and format or at the program operator's discretion, and also in the form of independent audits mandated by the regulators. Table 1 summarizes the four countries' programs.

Table 1. M&V Summary for the Main European Energy Efficiency Obligation Programs

	UK	**Italy**	**France**	**Denmark**
M&V Options	Deemed savings Case-by-case approval for other measures	Deemed savings Engineering approach Metered baseline method	Deemed Savings Case-by-case approval for other measures	Deemed savings Engineering calculations
Dominant M&V Choice	Deemed savings	Deemed savings	Deemed savings	Engineering calculations
Accreditation of Savings	Ex ante	Ex ante (majority) and ex post	Ex ante	Ex ante (first-year savings)

Source: Navigant

Italy

The Italian White Certificates program combines three methodologies reporting savings: deemed savings, engineering approach, and monitoring methodology.

- **Deemed savings.** This methodology is based on the use of technical sheets that are developed by the Italian Regulatory Authority for Electricity Gas and Water (Autorità per l'energia elettrica il gas, or AEEG), which include predetermined savings per technology and default rates for additionality and delivery. The savings for measures using this methodology are ex ante estimates and are considered constant annually for the duration of the life of the measure. There is no physical measurement involved with this type of measures and all the analysis is conducted within each technical sheet for each measure.

- **Engineering approach.** It is based on the use of standardized technical forms prepared by the Italian Economic Development Ministry. This methodology involves a limited amount of

on-site measurement around factors that affect the estimated savings of a measure (e.g., working hours). The formulas to estimate savings are quite simple but provide some flexibility since the annual savings can be adjusted and needn't be constant for each year.

- **Monitoring methodology.** It is used for measures that are more customizable and require the development of a full energy monitoring plan. This is to be submitted for approval with the regulator and must include a clear description of how the savings will be calculated, the baseline and the relevant assumptions to support it, and the procedure to collect and analyze the data from on-field measurement (before and after the implementation). This methodology uses savings based on measurement and verification, not based entirely on ex-ante estimates such as the deemed methodology and the engineering methodology.

Since 2005, about two-thirds of the approved measures in the Italian White Certificates program have been submitted as deemed measures (Di Franco & Bisello 2013).

Verification of savings in the Italian White Certificates program is done ex ante for deemed measures and ex post for the measures under the monitoring methodology. For the measures under the engineering approach, the verification is also done ex post after the field measurements are taken. AEEG reserves the right to conduct audits at its discretion for measures under any of the described methodologies.

United Kingdom

The British Energy Companies Obligation (ECO) program was launched in 2013 and it has replaced the Carbon Emissions Reduction Target, which ran between 2008 and 2012, and the Energy Efficiency Commitment, which ran from 2005 to 2008. The program is focused on carbon emissions reductions, and places emphasis on building retrofits for vulnerable households.

The program is based on a list of deemed measures which suppliers can use to meet their ECO obligations and are outlined in the ECO Measures Table. Each measure listed in the table is associated with a "Lifetime" and an "In-Use Factor", two data points that are then used in the calculation of the carbon savings. The list of measures in the table is nonexhaustive and suppliers can apply it to the Office of Gas & Electricity Markets (Ofgem) to use separate values for Lifetime and In-Use Factor for new measures not included in the table.

Savings are attributed to suppliers through monthly notifications they submit to Ofgem for the measures they have installed. Ofgem in turn has set in place a verification system to confirm the information provided by the suppliers based on technical monitoring conducted by independent parties at a sampling rate that is determined by the average failure rate a supplier has demonstrated in the monitoring plan over the course of three consecutive quarters.

France

The French Energy Saving Certificates program is made of "eligible actions", which are no different than deemed measures. At the moment, there are more than 200 standardized action sheets that outline the predetermined savings for energy efficiency measures through a standard ex ante methodology (Zahm A-L 2013). Suppliers can propose the use of actions that are not in the list of standardized measures; however, that option is exercised very rarely (about 2 percent of the energy-saving certificates delivered by 2011 [Greaume & Borde 2011]). The energy savings are calculated for the whole lifetime of the measures and are discounted.

The verification of the savings in the French program is done via the submitted documentation. The suppliers are requested to submit proofs for contribution, reality of action, conformity with installation quality criteria, and absence of double-counting. Also, they are required to submit invoices that have been generated by the installers and documentation that proves the installers' qualifications. This process is done electronically in the same platform where the Energy

Saving Certificates can be traded between the program participants (www.emmy.fr).

The French Ministry of Energy maintains the right to audit measures and ask for proof of ex post savings. In the case of noncompliance, a penalty can be handed out which is twice the the penalty for a supplier not fulfilling its energy savings goal at the end of an obligation period (€4/kilowatt-hour [kWh] vs. €2/kWh) (Baudry & Osso 2011).

Denmark

The energy savings in the Danish program are measured from standardized average values for deemed measures or from engineering calculations for measures that have no standardized value. The former is used mostly in measures for the residential sector whereas the latter is in use more widely in the industrial sector and for larger, integrated projects. In contrast to the programs operated in France and Italy, the use of deemed measures is not the dominant methodology in the Danish obligation program, where the use of engineering estimates is more common. This has been attributed to the fact that that the program has seen greater success in the industrial and commercial sectors rather than in the residential (Budgaard et al. 2013).

For the deemed methodology, the Danish Energy Agency is maintaining a catalog of eligible measures. The savings are calculated only as first-year savings and are not cumulative. A multiplication factor is applied to the savings depending on the projected lifetime of the measure, which weights longer-lived measures more heavily, although not directly proportional to lifetime (i.e., measures with a lifetime over 15 years have a multiplication factor of 1.5 over their projected savings).

The engineering calculation methodology involves developing an ad hoc savings plan for each project based on predetermined operating conditions and assumptions. The plan is submitted to the Danish Energy Agency, which needs to validate it. The verification of the energy savings for this methodology is the same as with the deemed measures; there is no ex post measurement and the savings are attributed based on the submitted documentation.

The verification of the savings in the Danish program is achieved through self-control. Specifically, the obligated parties (distribution companies) are required to establish internal control and quality assurance mechanisms that ensure that the submitted documentation to the regulator is true and correct. An additional requirement is that the distribution companies conduct an annual audit of their reported savings. The Danish Energy Agency conducts annual random inspections among the distribution companies, with the penalty for overreporting savings being the requirement to provide extra savings the following year equal to the savings that have been found incorrect (Budgaard et al. 2013).

U.S. Protocols

The U.S. evaluation environment has produced many protocols. These have been created by state, regional, national, and professional organizations. A recently released Roadmap from the American National Standards Institute (ANSI) reviewed existing standards and protocols used in the U.S. and identified gaps to be addressed in coming years (American National Standards Institue, 2013). Some of the more significant protocols are discussed below.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guideline 14, Measuring Energy and Demand Savings

ASHRAE Guideline 14 (ASHRAE 2001) provides detail on implementing M&V plans. It contains detailed information on quantifying and minimizing uncertainty in M&V plan design, data acquisitions system selection and design, sensor selection, sensor placement, and calibration. It addresses the whole building approach (billing analysis), retrofit isolation (measuring key parameters

defining energy use of a system), building simulation, and instrumentation and data management. It provides a detailed discussion of calibrated simulation modeling. It does not address evaluation, net-to-gross, or process evaluation. It is specifically focused on commercial installations.

California Evaluation Framework

The California Evaluation Framework (TecMarket Works 2004) was an effort to develop a consistent, systemized, cyclic approach for planning and conducting evaluations of California's energy efficiency and resource acquisition programs. It addresses evaluation planning, impact evaluation, measurement and verification, process evaluation, information and education program evaluation, market transformation program evaluation, non-energy effects evaluation, uncertainty, sampling, and cost-effectiveness. It discusses skills needed to conduction evaluation. Net-to-gross considerations are included as a part of evaluation.

California Evaluation Protocols

These protocols (TecMarket Works 2006) are used to guide the efforts associated with conducting evaluations of California's energy efficiency programs and program portfolios. The protocols were intended to serve as the primary guidance tools policymakers use to plan and structure evaluation efforts and that staff of the California Public Utilities Commission's Energy Division and the California Energy Commission use to plan and oversee the completion of evaluation efforts. The protocols are also guidance documents evaluation contractors use to design and conduct evaluations for programs. The protocols are grounded in the California Evaluation Framework. They address impact evaluation, M&V, emerging technologies, codes and standards, effective useful life, process evaluation, market effects, sampling and uncertainty, and reporting.

Model Energy Efficiency Program Impact Evaluation Guide

This guide (U.S. Environmental Protection Agency and the U.S. Department of Energy 2007) is designed for energy efficiency program designers and evaluators looking for guidance on the evaluation process and key issues relating to documenting energy and demand savings, documenting avoided emissions, and comparing demand- and supply-side resources. It focuses on impact evaluation of programs, and addresses gross savings estimation, net-to-gross estimation, and avoided emissions calculations. It primarily focuses on ex post approaches, but does include discussion of deemed savings.

Regional Technical Forum (RTF) Guidelines

The RTF (Regional Technical Forum 2013) provides for four savings estimation approaches for use in the Northwest U.S.:

1. **Unit Energy Savings (UES)** – These are deemed savings, appropriate for measures whose unitized savings (e.g., savings per lamp or motor) is stable (both the mean and variance) and can be reliably forecast through the period defined by the measure's sunset date (e.g., domestic hot water showerheads). The UES method is appropriate for measures whose unitized savings (e.g., savings per lamp or motor) is stable (both the mean and variance) and can be reliably forecast through the period defined by the measure's sunset date. Savings are a function of the verified count of delivered units, and the information needed to assign a specific application of the measure (e.g., single-family residence with forced-air furnace in western Washington of the Cascades).

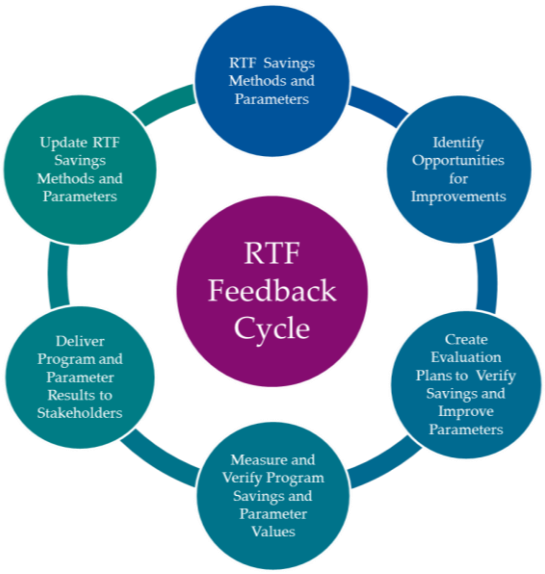
2. **Standard Protocol** -- Appropriate when savings from a measure are widely varying but can be determined by a standardized procedure for data collection and analysis that is applicable to many different end-use sites (e.g., motor variable frequency drives)

3. **Custom Protocol** -- Appropriate for measures that require site-specific savings estimation planning, data collection, and analysis in order to develop a reliable estimate of savings

4. **Program Impact Evaluation** -- Estimate savings from a period of program operation

The RTF guidelines make a point of intentionally not using the terms "net" or "gross" to modify the term "savings," as they may conflict with their intended definition of "baseline", which seeks to define directly the conditions that would prevail in the absence of the program (the counterfactual), as dictated by codes and standards or the current practices of the market. The RTF uses a baseline characterized by current market practice or the minimum requirements of applicable codes or standards, whichever is more efficient, so free ridership or spillover may be included in the results. However, not all analysts and authors are in agreement on the relationship between such baselines and how they comport with long-standing definitions of gross and net impacts or related issues such as program self-selection bias.

RTF has a feedback process that provides the framework for development of improved UES values and/or evaluation methods, as illustrated in Figure 1.



Source: Navigant

Figure 1. RTF Provides a Feedback Process for UES Improvement

Uniform Methods Project Protocols

The Uniform Methods Project (U.S. Department of Energy, 2013) provides a set of model protocols for determining energy and demand savings that result from specific energy efficiency measures implemented through state and utility efficiency programs. The objective for the project was to establish easy-to-follow protocols based on commonly accepted methods for a core set of commonly deployed energy efficiency end uses measures. The initial-phase protocols addressed the following:

- Commercial and Industrial (C&I) lighting
- C&I Lighting Controls

- Small Commercial and Residential Unitary and Split-System Heating, Ventilating, and Air Conditioning Cooling Equipment-Efficiency Upgrade
- Residential Furnaces and Boilers
- Residential Lighting
- Refrigerator Recycling
- Whole-Building Retrofit with Consumption Data Analysis
- Metering
- Peak Demand and Time-Differentiated Energy Savings
- Sample Design
- Survey Design and Implementation
- Persistence and Other Evaluation Issues

The second phase of the project is addressing other types of measures and net-to-gross.

California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects

The California Standard Practice Manual (Governor's Office of Planning and Research State of California, 2002) is the common reference for cost-effectiveness tests in the U.S. It identifies the cost and benefit components and cost-effectiveness calculation procedures from four major perspectives: Participant, Ratepayer Impact Measure (RIM), Program Administrator Cost (PAC, also known as Utility Cost), and Total Resource Cost (TRC). A fifth perspective, the Societal, is treated as a variation on the Total Resource Cost test. The manual provides formulas to calculate the net present value of program impacts over the lifecycle of those impacts.

Conclusions

With the rapid expansion of energy conservation programs in different parts of the world, the need to develop robust and compatible evaluation, measurement, and verification protocols is indeed great. The expansion of existing, and the launch of new, international programs like the UN-CDM and the EU-ETS highlight even more clearly the need for standardization in the terms and processes of energy savings measurement and verification. There are several different protocols on either side of the Atlantic, most of which are designed to fit the purpose of the program for which they will be used.

In Europe, the different national energy efficiency obligation programs have developed separate rules that nevertheless combine similar elements. The dominant methodology for the measurement of savings is the use of deemed measures, where each measure is assigned to an ex ante, predetermined level of savings. The use of measured data and field observations is limited. As a result of the increased use of deemed measures in the European market, there are not significant provisions for proving additionality at the project level. The common practice is to use an NTG ratio at a program level for each measure, which is reexamined and revised every few months (usually annually).

In the U.S., protocols are more oriented towards ex post measurement and verification. The use of metering, site inspection, billing analysis, and calibrated simulation models with post installation data on projects and measures is standard practice. The reliance on empirical data give more rigour than reliance solely on engineering theory.

Both sides of the Atlantic consider the issue of what would have happened in the absence of the program or project, but with different terminology—net-to-gross in the U.S. and additionality in Europe.

Harmonizing these protocols will facilitate international trade in the energy efficiency industry and the development of international agreements for climate change mitigation. Having

consistent protocols will allow energy services companies to more easily work on either side of the Atlantic without having to learn new systems. Consistent protocols will give policy makers greater confidence that an estimate of greenhouse gas reduction has the same meaning in either hemisphere.

Some considerations in this harmonization:

- Agree on consistent terminology.
- Increase use of ex post data in European energy efficiency obligation schemes
- European's may want to consider approaches to project-level additionality for NTG estimates used in the U.S.
- Expand process for improving savings estimates, on both sides of the Atlantic
- Increase availability of smart meter interval data, which will provide for increased evaluation rigor

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