DE-FOA-0001472/0001: Request for Information (RFI)
Energy Savings Prediction Methods for Residential Energy Efficiency Upgrades

DATE: December 16, 2015
SUBJECT: Request for Information (RFI)

Description

The United States (U.S.) Department of Energy (DOE), Energy Efficiency and Renewable Energy (EERE), Building Technologies Office (BTO) is seeking information from the public regarding methods to improve methodologies used to assess the energy savings resulting from energy efficiency upgrades. In particular, BTO is interested in the current state-of-the-art of savings prediction methods, forthcoming advances that could improve the accuracy and/or reduce the costs of prediction methods, and the potential market implications of improved savings prediction methods. At the same time, BTO is interested in the role of user-training, contractor certification, better in-field practices, and other factors to improve the accuracy of energy saving calculations.

Background

BTO's mission is to develop, demonstrate, and accelerate the adoption of energy efficient technologies, techniques, tools, and services for residential and commercial buildings in both the new and existing buildings markets. BTO has established an overarching long-term goal to reduce the energy use per square foot of U.S. buildings by 50% compared to 2010 levels.

Residential buildings in the U. S. use an estimated 21 quadrillion Btu (quads) of energy and account for approximately 21% of the United States total energy consumption[1]. BTO's Building America program, DOE's premier applied R&D initiative for residential buildings, has produced more than 100 innovations that have helped households across the nation save $54 billion since 1995, and led to stronger building codes that offer 35% greater savings than those of 20 years ago. Many homes could reduce energy use even further through energy efficiency upgrades—by 20% or more, saving homeowners more than $36 billion annually[2] in energy costs. To accelerate these savings, BTO wants to ensure it uses the most up-to-date and

[1] U.S. Energy Information Administration. Annual Energy Outlook 2014 with projections to 2040. DOE/EIA-0383(2014). Washington, DC: U.S. Department of Energy, April 2014. http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf

[2]Assumes 20% savings for 78.6 million single-family homes with a total annual energy expenditure of $181.2 billion according to the 2009 Residential Energy Consumption Survey Table CE1.1 Summary Household Site Consumption and Expenditures in the U.S.

accurate methods possible for assessing the appropriateness and cost-effectiveness of installing various energy efficiency measures in homes. Through this RFI, BTO is seeking input from the public to improve its methods for predicting[3] the energy savings that result from energy efficiency upgrades to residential buildings.

A recent evaluation of DOE's Better Buildings Neighborhood Program (BBNP) indicated that – while overall savings for upgraded homes averaged 15%[4]-- Grantee-predicted savings for individual homes were generally greater than savings calculated through a regression analysis of pre- and post-upgrade metered energy consumption data for a sub-sample of residential upgrade projects with sufficient data (BBNP Impact Evaluation Vol 2). The savings prediction calculations used by the BBNP Grantees included a range of methods such as simple engineering calculations to building energy simulation. A gap between predicted and verified energy savings is not unique to the BBNP program. Another example where a gap between predicted and verified energy savings was observed includes:

- A 2015 study of project-level realization rates for a sample of homes participating in the New York State Energy Research and Development Authority (NYSERDA) Home Performance with ENERGY STAR program found that:
    - The building energy simulation predictions of natural gas energy savings were generally greater than meter based savings;
    - Retrospectively applying Building Performance Institute Standard 2400-2012 (BPI, 2012) model calibration principles improved median natural gas project-level realization rates. (NYSERDA, 2015)

Energy savings predictions are often used to assess the cost-effectiveness of energy efficiency upgrades. Thus, accurate predictions of energy savings are important for efficiency programs, homeowners, and other stakeholders who invest in energy efficiency improvements. BTO is interested in information on a broad array of approaches for reducing the gap between predicted and verified energy savings. Such approaches could include, but are not limited to, improved training, certification, and data collection procedures; improved published standard default assumptions and calculation methods; improved analysis tools and software validation methods; and auditor and modeler feedback and evaluation using measured performance data.

Energy Savings Prediction Methods

[3] E.g., at the time of an energy audit.
[4] Table ES-4 on page ES-6, BBNP Impact Evaluation Volume 2

Prediction methods can generally be categorized according to the underlying calculation approaches they use and how those calculation approaches are specifically applied in energy efficiency programs.

Underlying Calculation Approaches

Example categories of underlying calculation approaches used to predict the energy savings that will result from residential efficiency upgrades include:

- **Simple Engineering Calculations:** In some cases simple calculations are performed based on engineering principles to predict the energy savings that will result from energy efficiency upgrades. For example, if a lighting product of a known wattage is being replaced by a lighting product of a known and lesser wattage, the savings can be estimated based on the wattage difference, the estimated annual hours of operation, and an adjustment factor that accounts for the effect of the internal heat gains from the light on space conditioning energy consumption.
- **Building Energy Simulation:** A variety of computer software programs have been developed that predict the thermal performance of buildings and their mechanical systems based on detailed physics-based models that account for complex interactions between energy systems within the home. These software programs often simulate whole-building energy consumption at hourly or sub-hourly time-steps.
- **Metered Data Analysis:** A variety of mathematical methods have been developed to analyze metered energy consumption data and estimate the savings that results from energy efficiency upgrades. For example, statistical multiple-linear regression models can be developed using pre-upgrade and post-upgrade metered energy consumption data from many upgrade projects implemented in the past. These statistical models can be used to estimate the savings that will result from similar future upgrade projects.

There may also be approaches that fall outside of these categories or that combine approaches across categories (e.g., calibration of building energy simulation models to pre-upgrade metered consumption data). For example, recent technological advancements in infrared scanning technologies, computer access and manipulation of publically available housing data and sensors possibly present opportunities to reduce the cost of energy assessments, lessening the need for detailed measurements within the home.

Application of Approaches in Energy Efficiency Programs

The underlying calculation approaches described above can be used to generate highly-customized savings estimates for individual homes, or they can be used to estimate average savings values for specific types of upgrades across many homes (sometimes referred to as "deemed" savings values). For example, when using building energy simulation to predict energy savings for an individual home, it is common to first develop an energy model to estimate energy consumption for the home before the upgrades. This is called the baseline energy model. The baseline energy model may be calibrated to historical metered energy consumption data for the home (e.g., following procedures outlined in BPI 2400-S-2012). Then the baseline energy model is modified to estimate energy consumption after energy upgrades are installed in the home[5]. Both the baseline and post-upgrade models are used to predict annual energy consumption under the same weather conditions (e.g., using typical meteorological year weather) and the annual energy savings is calculated by subtracting the predicted post-upgrade energy consumption from the predicted baseline energy consumption. As an alternative example, building energy simulation can be performed using prototypical homes in a region to develop average savings values or calculation procedures for specific types of upgrades. How a calculation approach is applied influences the accuracy of predictions. For example, deemed savings estimates may be representative of the average savings across many homes, but the savings of a specific home may be more or less than the average.

Evaluation of Energy Savings Predictions

The performance of residential savings prediction methods is often evaluated based on how well savings predictions align with savings estimates[6] derived using metered consumption data after the upgrade (hereafter referred to as "meter-based savings"). Although meter-based savings are estimates that have their own potential biases and uncertainties, these are often thought to be small relative to the potential biases and uncertainties of energy savings predictions made near the time of the retrofit. Meter-based savings calculation methods vary depending on the purpose of the analysis. For example, when calculating savings for individual homes using whole-house metered energy consumption data from before and after the upgrade(s), utility billing regression analysis approaches are sometimes used[7]. When performed for an energy efficiency program evaluation, meter-based savings calculations may be used to verify reported energy savings estimates (DOE 2012).

Potential Causes for the Gap between Predicted Energy Savings and Meter-based Estimates

There are several potential explanations for why predicted energy savings may differ from meter-based savings. For example, some potential causes of differences between savings

[5] If the analysis is intended or required to characterize energy savings under standard occupancy assumptions, related inputs may be fixed or overridden in the energy model according to such standards.

[6] As described in [DOE 2012], "there is no direct way of measuring energy savings, because one cannot measure the absence of energy use. However, the absence of energy use (i.e., savings) can be estimated."

[7] Approaches may be similar to those described in the International Performance Measurement and Verification Protocol (IPMVP) Option C or the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guideline 14 "Whole Building Approach."

predicted using building energy simulation[8] and meter-based savings include (but are not limited to):

1. Causes related to the prediction of energy savings using building energy simulation
    a. Causes related to energy model inputs. For example,
        i. How and what energy audit data are collected, assumed, stored, transferred, quality-checked, cleaned, calibrated, etc. Relevant factors include the expertise, certification, and tendencies of the energy auditor; unintentional human error; and standard procedures for collecting, transferring, and calibrating data.
        ii. How and what default inputs are developed by the energy modeler or fixed within the energy model. Relevant factors include published standard default assumptions and calculation methods.
        Note: Types of data can include, but are not limited to, descriptions of the home (e.g., geometry, material physical properties, and characteristics of mechanical equipment); occupant inputs (e.g., occupant schedules and occupant-controlled equipment settings); and site inputs (e.g., local weather, soil, adjacent structures and vegetation).
    b. Causes related to physics algorithms & coding errors. For example,
        i. Inaccuracies in mathematical modeling of the physical behavior of the building and its equipment
        ii. Typographical and logical errors inadvertently introduced into the energy model software code

2. Causes related to the calculation of meter-based savings
    a. Causes related to the data used for the analysis. For example,
        i. How and what types of data are collected, stored, transferred, quality-checked, cleaned, etc.
        Note: Types of data can include, but are not limited to, metered consumption data, weather data, retrofit project data, and occupancy data
    b. Causes related to the algorithms used for the analysis. For example,

[8] Examples are presented for building energy simulation prediction methods applied to individual houses (some causes are adapted from Polly et al. 2011, which were originally based on Berry and Gettings 1998 and Judkoff and Neymark 2006). The potential causes of differences will depend on the prediction method used, including whether it is applied to individual homes or used to develop average savings values and calculations.

i. Potential biases and uncertainties in the methods used to analyze data and estimate savings (e.g., statistical modeling techniques).

3. External causes that sometimes influence meter-based savings calculations but not building energy simulation predictions. For example,
   a. Changes in occupancy and occupant behavior from pre- to post-retrofit periods (e.g., changes due to economic factors, changes in amount of secondary heating fuel use)
   b. Retrofit measures not implemented as prescribed or anticipated
   c. Changes to the energy features of the home during the pre- and/or post-retrofit periods that are not related to the upgrades being analyzed.

Understanding which causes have the most influence on the differences between predicted energy savings and meter-based savings can help prioritize future research efforts.

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on how to improve savings prediction methods for residential energy efficiency upgrades. BTO is interested in information on the current state-of-the-art of savings prediction methods, forthcoming advances that could improve the accuracy and/or reduce the costs of prediction methods, and the potential market implications of improved savings prediction methods. However, BTO is also interested in other factors that may influence the accuracy of modelled predictions such as improved field guidance, technician training and certification, or benchmarked models to a nationally accepted DOE prediction model such as EnergyPlus. In all cases, BTO is interested in likely costs incurred for each recommendation. Also, BTO is interested in developing alternative approaches that may now be possible with advancements in data collection and manipulation that could significantly reduce audit cost and homeowner inconvenience. Lastly, BTO is interested in the trade-off between cost and accuracy of all suggested approaches. This information will be used by BTO for strategic planning of the BTO research & development (R&D) portfolio. This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications for research on this topic at this time.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Proprietary Information

Because information received in response to this RFI may be used to structure future programs and FOAs and/or otherwise be made available to the public, **respondents are strongly advised to NOT include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.** If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

> **Notice of Restriction on Disclosure and Use of Data:**
> Pages [List Applicable Pages] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI DE-FOA-0001472. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

In addition, (1) the header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure" and (2) every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Categories and Questions

Information is sought in response to three categories of questions related to improving savings prediction methods for residential energy efficiency upgrades. The categories and questions follow:

Category 1: Current State-of-the-Art

1.1. What methods represent the current state-of-the-art for predicting the energy savings that will result from energy efficiency upgrades in residential buildings? For each method, please specify as much of the following as possible:

1.1.1. A general description of the method, including A) categorizing the underlying calculation approach as a Simple Engineering Calculations, Building Energy Simulation, Metered Consumption Analysis, or Other, and B) categorizing if the underlying calculation approaches is intended to be applied to an individual homes receiving an upgrade, used to develop average savings values, applied broadly across many homes and measures, or other.

1.1.2. The conditions where it is appropriate to apply the method, including building types,[9] sizes (in gross sq. ft.[10]), locations, and types of energy efficiency upgrades.

[9] Residential building types include single-family detached, single-family attached, multi-family/apartment, and mobile homes.

[10] Gross square feet, for the purposes of this RFI, is defined as the entirety of the plan area enclosed by a building's exterior walls, including elevator shafts, stairwells, hallways, atriums, closets, and other ancillary spaces.

1.1.3. Information related to the data used for the method (e.g. how data are collected, stored, transferred, quality-checked, cleaned, filled, calibrated, defaulted, etc., where applicable), including references to training and certification programs, standards, guidelines, procedures, computer software, etc. that are utilized.

1.1.4. Information related to how energy savings are predicted (e.g., general descriptions of the mathematical models for physical behavior of the building and the numerical and computational methods used to implement the models), including references to training and certification programs, standards, guidelines, procedures, computer software, etc. that are utilized.

1.1.5. The types of predictions that can be obtained using the method (e.g., annual energy savings, prioritization of potential efficiency upgrades)

1.1.6. Descriptions of instances where savings predictions using the method have been compared to meter-based savings, including:

1.1.6.1. A summary of what are believed to be primary causes of differences, the relative magnitudes of influence each cause has on the differences, and supporting evidence (see example causes of differences in the Background section above)

1.1.6.2. References to detailed documentation of the comparisons (e.g., published reports)

1.1.7. Examples where standard occupant behavior assumptions used within the prediction method may not agree with real world observations.

1.1.8. Information about the costs associated with developing, maintaining, and applying the savings prediction method. Please include estimates of the amount of time taken to collect data on an existing home.

Category 2: Forthcoming Advances

2.1. What are appropriate metrics and approaches for evaluating the performance of energy savings prediction methods and quantitative performance targets for those metrics?

2.2. What improved methods are currently under research or investigation to overcome common causes for differences and advance the state-of-the-art? BTO is interested in information on a broad array of approaches for improving methods, which could include, but are not limited to, improving training, certification, and data collection procedures; improved published standard default assumptions and calculation methods; improved analysis tools and software validation methods; and provided auditor and modeler feedback and evaluation using measured performance data.

2.2.1. What advantages are these methods intended to have over those that are currently used?
2.2.2. What are the limitations of these methods (e.g., cost, speed, complexity, accuracy) or what additional research is required before they can be used widely?
2.2.3. Are there intermediate innovations or key enabling technologies that require R&D before improved savings prediction methods are possible? What are these enabling technologies or innovations?

2.3. What R&D opportunities remain for improving the performance and/or reducing the cost of existing savings prediction methods? To what extent can savings prediction methods be improved?

Category 3: Market Needs, Barriers, and Opportunities

3.1. What market structures and forces have the most influence on the performance of savings prediction methods? What market barriers or other challenges, if any, prevent the wider use of existing state-of-the-art savings prediction methods?

3.2. What are market-acceptable costs and time requirements for predicting energy savings of residential energy efficiency upgrades?

3.3. What effects will improving savings prediction methods have on the adoption of residential energy efficiency upgrades?

3.4. What market opportunities would be created by widespread availability of improved savings prediction methods? What specific capabilities are required from these improved savings prediction methods to unlock the market opportunities identified?

3.5. What level of energy savings prediction accuracy is acceptable to the market?

3.6. What role should the federal government play within this topic area?

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to ResEnergySavingsRFI@ee.doe.gov no later than 5:00pm (ET) on February 21, 2016. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 5 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

References:

DOE 2012
State and Local Energy Efficiency Action Network. 2012. Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.seeaction.energy.gov.
http://energy.gov/sites/prod/files/2013/11/f5/emv_ee_program_impact_guide.pdf

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ASHRAE Guideline 14
https://www.ashrae.org/standards-research--technology/standards--guidelines/titles-purposes-and-scopes#Gdl14

IPMVP
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BPI 2400
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