Northeast Energy Efficiency Partnerships

Load Shape Catalog Project Summary and Recommendation for Future Research

Date: June 2016

About NEEP & the Regional EM&V Forum

REGIONAL EVALUATION,
MEASUREMENT & VERIFICATION FORUM

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate energy efficiency in the building sector through public policy, program strategies and education. Our vision is that the region will fully embrace energy efficiency as a cornerstone of sustainable energy policy to help achieve a cleaner environment and a more reliable and affordable energy system.

The Regional Evaluation, Measurement and Verification Forum (EM&V Forum or Forum) is a project facilitated by Northeast Energy Efficiency Partnerships, Inc. (NEEP). The Forum's purpose is to provide a framework for the development and use of common and/or consistent protocols to measure, verify, track, and report energy efficiency and other demand resource savings, costs, and emission impacts to support the role and credibility of these resources in current and emerging energy and environmental policies and markets in the Northeast, New York, and the Mid-Atlantic region.

Acknowledgements

NEEP and DNV GL thank the sponsors of the EM&V Forum from NH, VT, MA, RI and CT for their support of this project and for the assistance of subcommittee members from these states who volunteered time to assist in development of this project.

About DNV GL

DNV·GL

DNV GL is a global classification, certification, technical assurance and advisory company serving the maritime, oil and gas, and energy sectors, with 16,000 employees in over 100 countries. In the energy sector, DNV GL is a recognized international leader in the efficiency program evaluation and markets. Our senior staff has pioneered the development of evaluation concepts, methodologies, and tools currently being used by practitioners throughout the United States and abroad. Our experience cuts across a wide range of evaluation goals and disciplines, touching on virtually every type of program, technology, and targeted sector.

Introduction

The Regional Evaluation, Measurement and Verification Forum (EM&V Forum) and the Northeast Energy Efficiency Partnership (NEEP) regularly commission projects intended to help improve and ensure the understanding, transparency, and credibility of energy efficiency resources implemented in the Northeast, New York and mid-Atlantic region. DNV GL has worked with NEEP, its technical consultants and the EM&V Forum to develop a Load Shape Catalog that would assist forum members in estimating the annual energy and peak demand savings of their Energy Efficiency (EE) programs. This report provides a high level summary of the Load Shape Catalog, the studies and measures reviewed as part of its development, and observed gaps in data that suggest opportunities for future research. We note that the primary deliverable for this project is the Catalog itself, which includes a navigation page, field definitions table, a detailed accounting of the sources reviewed and included in the Catalog, and the Catalog data itself.

An Overview of the Load Shape Data Catalog

The Load Shape Catalog itself is the compilation of energy and peak demand savings parameters that have been gathered from studies performed in the region. The objective of the Load Shape Data Catalog is to help reduce the overall cost of impact evaluation by making available secondary data to either supplement or offset the need for new studies with primary data collection. The Catalog has been designed to gather and structure information from regional studies that can be used to support users in several ways. The Load Shape Catalog exists to support user determination of annual energy and peak demand savings for regulatory reports, the calculation of capacity values in regional capacity markets, the estimation of capacity and energy benefits in program benefit-cost analyses and program emissions savings for the purpose of air quality regulation modelling. The following are the primary activities and objectives undertaken:

- Secondary Data Research. DNV GL and NEEP identified recent metering-based impact evaluations and end-use load shape studies from the region for catalog consideration. Criteria for inclusion in the Catalog included the need for parameters to be based on primary data collected for the study or vetted for relevance and used for the study and approximately 10 sample points for simple end uses such as indoor lighting and 15 sample points for more complex end uses like VFDs or Refrigeration.
- Develop the Data Catalog. DNV GL examined reports identified in the secondary data research phase to collect the performance of equipment for the parameters of interest to the catalog (e.g., coincidence factors, hours of use, etc.). This effort sought to extract results and any needed supporting information in a manner that would not require additional analysis of the source data by the end user.
- Produce Documentation within the data catalog to support its use. This documentation includes an example of how to use the guide, key field definitions, a compilation of data sources reviewed, and the Load Shape Catalog itself.
- Recommend Future Research to identify other load shape-related research that would be beneficial to the region, and provide recommendations in consideration of evolving data requirements and evolving metering, data storage and processing technology. This document discusses our recommended research after describing the information included in the current Catalog.

The Load Shape Data Catalog spreadsheet is laid out as a wide dataset where each row represents a unique combination of type of equipment (e.g., prescriptive chiller, heat pump, lighting), sector, and jurisdiction identified from a qualified regional study. Each column provides the study parameters gleaned and any additional information available to guide their use; such as sample sizes, how the parameter was intended to be applied, the source report, and notes on other specifics of the study believed to be pertinent to understanding the parameter(s) provided. As

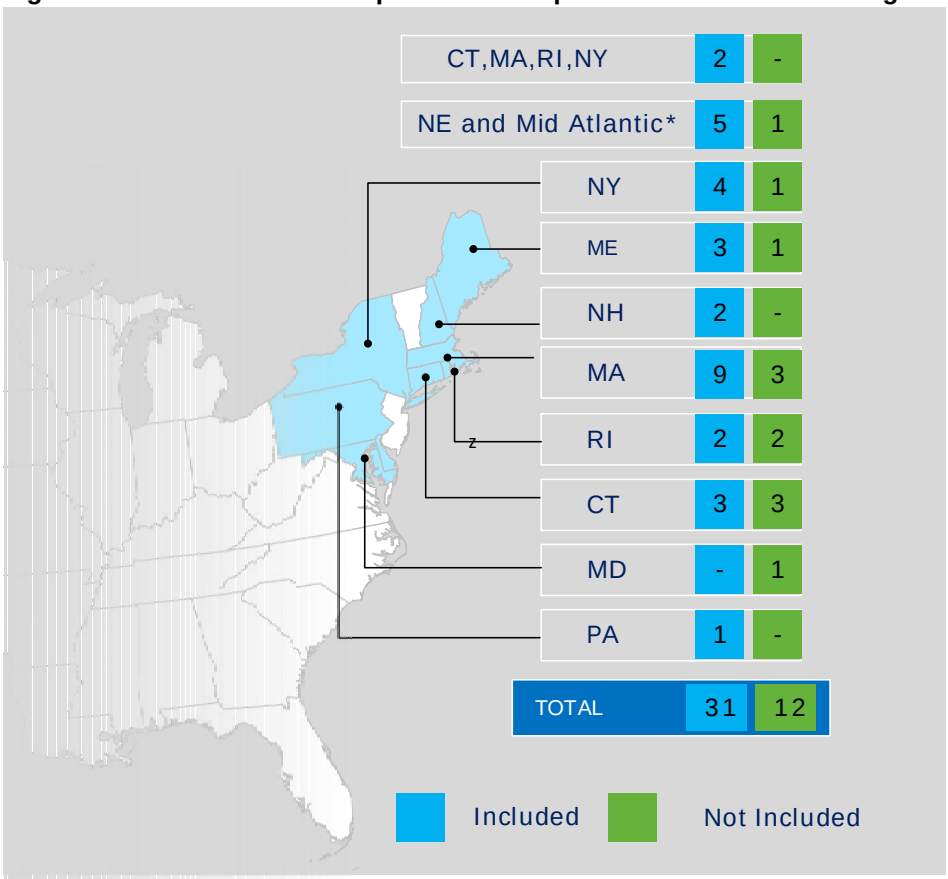
noted earlier, also accompanying the Load Shape Data Catalog are tabs that provide all field definitions and data sources reviewed as well as an example of how to use the guide.

The layout of the data provided in the catalog and the decision to develop it in Excel were deliberately made to support ease and flexibility of use. As detailed in the Guide Use Example tab, the catalog provides filters that allow the user to search and explore parameters by sector, measure/equipment type, program, state and vintage. This design allows the use of one or more filter selections to explore available parameter options, including the ability to compare and contrast field results when multiple parameters are available for consideration. The parameter sources (i.e., reports and load shape tools) have links within the tool to facilitate any further research a user might pursue before application of a parameter and each source has also been fully annotated within the catalog.

Summary of Research Included in the Load Shape Catalog

As indicated earlier, recent regional impact evaluations and end-use related load shape studies (including load shape tools) were compiled in the early stages of this study. In total there were 43 such studies that were reviewed for possible inclusion in the catalog. These studies are summarized in the figure below. We have footnoted those states included in studies performed throughout the Northeast and Mid Atlantic. Criteria for inclusion included the need for the parameter to be based upon primary data or data otherwise vetted for use in the study and a sample basis of approximately 10 or more data collection points. Figure 1 below provides the number of reports reviewed by state/region and whether they were ultimately included in the data catalog.

Figure 1. Jurisdiction and Disposition of Reports Reviewed for Catalog Inclusion



* Studies sponsored by a combination of states and jurisdictions that typically include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C.

The Load Shape Catalog is founded upon 31 studies performed over the last 7 years that cover diverse measures in the residential and C&I sectors. In drawing all of the various studies together in this effort, it is apparent that there has been a great deal of evaluation work done throughout the region spanning both the residential and C&I sectors. Table 1 shows the equipment types included in the catalog that serve the residential and/or C&I sectors. Note that some studies cover more than one measure type in this table, although always within the same sector and year. Recall, the sources used to populate the catalog are from the Northeast and the Mid-Atlantic States, with a majority from states in New England. We have footnoted those sources that were NEEP load shape studies. We also note that we were not able to include studies from the low income sector in the catalog as no sources were identified for inclusion.

Table 1. Summary of Load Shape Research Efforts

Year Published		C&I	Small C&I[b]	Residential
2010	Brushless Fan Motor			■
2011	C&I Lighting[a]	■	■	
	Unitary HVAC[a]	■	■	
2012	Dehumidifiers			■
	Ground Source Heat Pump			■
	CFL			■
	Lighting		■	
	Room Air Conditioners			■
	Lighting Controls		■	
2013	Advanced Lighting Design	■		
	Lighting Controls	■		
	Lighting Systems and Fixtures	■		
	Refrigerated LED Case Lighting	■		
	Room Air Conditioners			■
2014	Air Conditioner/Purifier			■
	All Bulbs			■
	Central Air Conditioning			■
	Clothes Washer			■
	VFD Cooling Water Pumps (CWP)	■		
	Dehumidifier			■
	Electric Water Heater			■
	Heat Pump			■
	Heat Pump Water Heater			■
	VFD Hot Water Pumps (HWP)[a]	■		
	Prescriptive Lighting	■		
	Refrigerator			■
	Commercial Refrigeration[a]	■		
	VFD Return/supply Fans (RF)[a]	■		
	VFD Water Source Heat Pump Circulation Pumps (WHP)[a]	■		
2015	Compressed Air	■		
	Prescriptive Chiller	■		
	LED Lighting	■		
	Process	■		
	Cooling	■		

a NEEP Load Shape Study
b C&I customers eligible for Small C&I Programs.

Suggestions for Future Research

There are several considerations we made in assessing gaps in the catalog and resulting suggestions for future research. We considered the length of time since the last study, the expected level of savings associated with the measure, the anticipated importance of a measure or technology moving forward and our general knowledge of impact studies in the region and the durability of their results. In our consideration of possible future research opportunities, we presume that either a study performed in one jurisdiction is transferrable to another or that sampling techniques will ensure representation of all regions or jurisdictions.

Following the discussion of future research ideas, we provide a brief high level recommendation related to implications that new industry developments have for current and future EM&V practices.

Small Business

A clear opportunity for additional evaluation is in small business load shape research. It has been roughly 4 years since the last substantial small business impact study has been completed. ISO NE FCM guidance provides a five year period before which DRV parameters should be re-examined. Small business programs are largely dependent on lighting measures, and a review of the small business evaluations performed suggests that impact results are typically stable. This may explain why there has been little impact evaluation activity in this sector recently. However, small business programs remain a significant component of most efficiency portfolios in the region and new small business initiatives being piloted in some markets (e.g., Customer Directed Options) may warrant new studies to update load shape parameters in this population.

C&I Lighting

The following three study suggestions all fall under the broad category of C&I lighting.

LED Lighting

Another gap that is somewhat hidden in the table is in C&I LED lighting in general, including indoor and outdoor applications. The study noted in the table above performed in 2015[1], which included some LED lighting, had a small sample size and was not dedicated to LED lighting. There is also an upstream impact study beginning in Massachusetts that is expected to include a lot of LED lighting. Since LED lighting is rapidly gaining popularity in the marketplace and is becoming an increasingly critical measure to efficiency programs and portfolios, the immediacy and level of study is noteworthy. LED lighting is unique from traditional linear fluorescent lighting as it is a more flexible technology in terms of being able to install a finer level of efficacy and is also often accompanied by more complex controls. These characteristics suggest that LED lighting may have more diverse schedules and uses with hours of operation and coincident factors that would differ from the linear fluorescent lighting typically studied in the past.

Lighting Load Shape

The NEEP lighting load shape study tool was completed in 2011. As mentioned above, LED technologies are rapidly emerging as the lighting of the future, but they were only found in a small portion of facilities in that study. There have been some substantive studies of C&I lighting performed in the last several years that make logger data for both linear fluorescent and LED lights available. In the lighting load shape report it was recommended that future work include further examination of seasonality and an emphasis on market sectors where they are prone to exhibit a high degree of seasonality (e.g., education and university-colleges). Under these circumstances, we believe a good candidate that would fill a value gap would be to update the C&I lighting load shape tool to include logger data

[1] New Hampshire Utilities Large Commercial and Industrial Retrofit and New Equipment and Construction Program Impact Evaluation, Final Report, September 25, 2015

collected since the original effort with a revision to the tool that allows users to output and examine results for LED lights in addition to linear fluorescent. An opportunity to build up sector-level sample sizes would accompany this effort, further supporting the use of the tool for users with different building profiles among their participant groups.

Lighting Controls

An important part of determining peak demand savings and associated parameters are the baselines from which they are based. Often times, these baselines are specific pieces of equipment that can be observed as a pre-condition or that can be studied in an equipment-specific baseline study. But in the case of lighting controls, such as occupancy sensors, we note an absence of baseline pre-installation primary data. Pre installation baseline operation used for calculating lighting control savings are often derived from assumed operation based upon trends observed in the controlled operation. While we are unsure how prevalent lighting controls will be as a measure in future programs, a lighting controls baseline study that incorporates pre-metering might be a valuable addition to the currently available studies presented. To our knowledge only one such study has been completed in the region[2]. Such a study may also prove useful to inform the evaluations of advanced lighting controls, which are becoming increasingily prevalent.

C&I HVAC Load Shape

The NEEP C&I HVAC load shape study tool was completed in 2011. The HVAC load shape tool was designed to calculate the peak and annual energy savings from the installation of typical high efficiency unitary direct expansion (DX) systems installed at commercial and industrial sites based on a specified load reduction. The data informing that tool is more than 5 years out of date and would benefit from the inclusion of more current data. The format of the underlying data can be appended to with additional datasets as gathered from studies performed since the tool was developed or from an effort explicitly designed to gather additional data.

Residential HVAC

Residential HVAC is becoming a larger portion of residential portfolio savings. There was a central air conditioning study published in 2014 with two summers of metering, a ground source heat pump study in 2014, as well as some recent work on Ductless Heat Pumps. However, to the extent that residential HVAC is expected to become more prominent in efficiency portfolios, studies of furnace fans and boiler pump replacements with EC motors appear to be gaps in the current body of evaluation studies examined.

Low Income

DNV GL had a difficult time finding low income studies with any catalog parameters of interest. Based on our experience, we suspect that savings for lighting measures installed in income eligible homes are informed by standard residential lighting parameters. Savings for income eligible measures such as envelope, insulation and air sealing are typically informed by billing analysis and similar methods that are unable to provide reliable savings parameter results beyond an overall or home level energy savings estimate. Given this observed gap and the potential for measures to perform differently in income eligible versus standard residential applications, we believe the region would benefit from low income studies supported by end use metering.

Emerging Technologies

As defined by ACEEE[3], emerging technologies are those that are either: (1) not yet commercialized but are likely to be commercialized and cost-effective for a significant proportion of end-users or (2) commercialized, but currently have

[2] Massachusetts Small Business Direct Install: 2010-2012 Impact Evaluations January, 29, 2013. The Cadmus Group. http://ma-eeac.org/wordpress/wp-content/uploads/Massachusetts-Small-Business-Direct-Install_2010-2012-Impact-Evaluations-1.29.13.pdf

[3] http://aceee.org/topics/emerging-technologies-and-practices

penetrated no more than 2% of the appropriate market. Emerging technology research the region may find valable include:

- Electric Vehicle Charging Stations with and without integrated Solar PV might present significant metering and load shape development research opportunities.
- Heat Pump Water Heaters were studied in 2014 in Maine and included 20 sampled sites with metering. Given the energy and demand savings potential for this technology, it continues to be an opportunity for further research in the region.
- Advanced Clothes Dryers won the US EPA emerging technology award in 2013 and 2014. These dryers can produce dramatic energy savings through the use of a combination of technologies that can include temperature and moisture sensor controls, heat pump, microwave, and even drum insulation and exhaust heat reuse.

Common Core Parameter Gathering and Use of Common EM&V Data Collection Protocols

During the course of this study, it was noted that there are often metering studies performed that produced specific parameters but did not generate all parameters of interest to the catalog. Ideally, studies with metered data would be designed to produce a common core set of parameters (i.e., those contained in the catalog). These core parameters could then be used to build up a body of knowledge for the region at large. However, we acknowledge that the narrow focus on parameters observed in many reports is likely due to the need to meet specific jurisdictional filing or reporting requirements within the finite budgets available to meet those requirements.

Though highly desired and valuable, we suspect that many studies would find the analysis and reporting of all catalog parameters to be impractical. Under these circumstances, there are two protocols developed by NEEP that the region would benefit from exercising. NEEP has developed an EM&V data collection protocol[4] to assist in regional efforts to develop load-shapes by making use of data gathered though meter-based evaluations. NEEP has also developed EM&V reporting methods[5] to help identify future studies that might be appended to this catalog. Use of these tools can be expected to facilitate future efforts to add to the Catalog through a more systematic way of gathering and storing metered data and the use of a more standardized identification of EM&V methods used in studies.

Framing Opportunities from Emerging EM&V Practices

A relatively recent Forum report, The Changing EM&V Paradigm[6] (December 2015, prepared by DNV GL) notes that there are several potential roles for automated M&V and advanced data collection methods to improve and streamline current EM&V practices. While these opportunities are discussed in Section 5.3.1 of that report, we note here that Program administrators and regulators may benefit from planning, conducting or sharing results of research that address such opportunities as:

- Automated energy consumption data analysis for individual facilities,
- Automated energy consumption data analysis for a group of facilities with an appropriately defined comparison group as a form of large-scale consumption data analysis,
- Incorporation of Automated Metering Infrastructure (AMI) whole-premise metering at higher frequency than monthly into whole-facility M&V or large-scale consumption data analysis,

[4] http://www.neep.org/data-collection-protocols-2012-0
[5] http://www.neep.org/sites/default/files/resources/Standardized_EMV_Methods_Summary_Forms_V1.0_Final_Sept_2014.pdf
[6] http://www.neep.org/changing-emv-paradigm

- Incorporation of decomposition of AMI data, and
- Metering of parameters such as temperatures or flows from advanced control or monitoring systems.