Taking Engineering Savings to the Next Level

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ABSTRACT

A skilled impact evaluation engineer can express a wide variety of energy impacts via traditional, spreadsheet-based analyses. In general, most energy efficiency measures are either schedule-dependent or weather-dependent, and to each, evaluators apply distinct evaluation approaches.

For NSTAR, the advent of the Forward Capacity Market (FCM) by ISO New England (ISO-NE) placed increased emphasis on the development of reliable estimates for participating demand resources. NSTAR instructed its large C&I evaluation contractors to adopt savings analysis methods with improved hourly rigor.

In general terms, gross savings estimates consist of the change in energy consumption or demand from the installation of energy efficient measures irrespective of the program influence. The type of savings analysis conducted to calculate the gross savings differs based on the type of measure installed and its dependence on ambient weather conditions. For NSTAR's impact evaluations, evaluators typically perform temperature bin analyses for weather sensitive measures and an hour-of-day analysis for non-weather sensitive or schedule dependent measures. But computing seasonal peak energy savings and coincident peak demand impacts via these methods requires some inherent assumptions about performance by month or across holidays. Accordingly, "traditional" coincident impacts are not particularly robust or true to peak period definitions.

For NSTAR, the Forward Capacity Market brings new demand definitions and a strict need for compliance, but also significant financial opportunities.

This paper demonstrates that 8,760 hourly savings analyses are a reliable and cost effective way of estimating accurate energy and coincident demand impacts as compared to the traditional bin analyses. The major advantage of an 8760-hour savings analysis is that in the future if the demand definitions change, the 8,760-savings load shapes can be used to calculate the savings for given definitions without modifications to the actual savings analysis.

Introduction

NSTAR Electric provides their customers an opportunity to reduce energy consumption by offering them an array of energy-efficiency programs. The most significant part of NSTAR's energy efficiency portfolio are the Business Solutions (BS) and Construction Solutions (CS) programs that are primarily targeted towards their large commercial and industrial (C&I) customers.

The Business Solutions program is focused on retrofit projects where as the Construction Solutions program is geared towards new facilities or major renovation projects. These programs are designed to provide the commercial, industrial, and institutional customers with financial and technical assistance to facilitate the installation of energy saving equipment in existing/new buildings.

The impact evaluation study is conducted by the utility in an effort to assess the effectiveness of its energy-efficiency programs and to compare the savings estimates projected prior to installation with the verified savings determined after the measure was installed. In addition, the findings from the evaluations help the utility to characterize the measure technologies and refine the delivery of the energy efficiency programs.

The evaluations involve on-site engineering assessments to calculate the gross energy and demand savings. A sample of sites was statistically generated for onsite assessments and net-to-gross surveys. Loggers were deployed at the site for data collection for approximately four weeks and savings analysis was performed using the logged data.

Historically, the evaluations involved calculating demand savings based on NSTAR's peak demand period definitions. However, NSTAR decided to bid the demand resource from their energy efficiency programs in ISO New England's Forward Capacity Market (FCM). FCM's objective is to purchase sufficient capacity for reliable system operation for a future year at competitive price where both new and existing resources can participate. ISO New England has its own coincident peak demand definition. As a result, the evaluation also required calculating demand savings based on ISO New England's peak demand period definitions. By the time the decision was made to include demand savings for FCM, the evaluation contractors had completed analysis for a few sites. While changing the completed analyses to include the demand savings as per ISO's peak demand definition, NSTAR decided to adopt an 8,760 savings analysis method. This paper describes the differences in results obtained from traditional methods and full 8,760 analyses in order to demonstrate that 8,760 analysis is an accurate and reliable way to calculate the savings analysis.

Types of Analyses and Typical Calculation Methods

A skilled impact evaluation engineer can express a wide variety of energy impacts via traditional, spreadsheet-based analyses. In general, most energy efficiency measures are either schedule-dependent or weather-dependent, and to each, evaluators apply distinct evaluation approaches.

Evaluation is primarily based on measured data. The measured data are examined to identify operating pattern of the equipment of interest in relation to parameters such as outside air temperatures, occupancy schedule, production rate, etc. The correlations obtained for the duration of measured data are used to extrapolate the savings analysis to the entire year. This can be done in number of ways depending on the type of savings analysis conducted. Typically, for weather dependent measures, a bin analysis is conducted. The bin analysis consists of arranging the annual temperature data, usually obtained from TMY2 or TMY3 weather data files for a nearby location, into pre-defined bins. The average temperature values for the pre-defined bins are used along with the correlations obtained from the measured data to calculate the annual energy and demand savings.

For measures that are not weather dependent, an hour-of-day analysis is typically conducted. The measured data are averaged for each hour of the day for all day types. Energy and demand savings are calculated for each of the hour bins.

8,760 Analysis Methodology

8,760 savings analysis essentially consists of calculating savings value for every hour of the year or 8,760 hours. This type of savings analysis also involves development of correlations similar to those developed for typical savings analysis described earlier. For weather sensitive measures, correlations are obtained between outside air temperatures and measured data using regressions. For non-weather sensitive measures, an averaged 24-hour operating profile is generated using the measured data. The way these data are processed is different for 8,760 savings analysis as compared to the traditional analysis. As described earlier, in traditional weather sensitive analysis the correlations are used in a bin analysis (average temperature bins) to obtain energy savings where as in 8,760 savings analysis, these correlations are used in conjunction with hourly temperature data to obtain the savings in that hour. Based on the actual site operating characteristics, the evaluator can conveniently modify the hourly calculations to reflect the operating schedule, site conditions or production trends. For NSTAR's impact evaluation, the hourly dry-bulb and wet-bulb temperatures were obtained from TMY3 weather data file for Boston.

Issues Related to Demand Savings Calculations

NSTAR has its own peak demand period definition which the evaluators have been using to calculate the demand savings. However, with the intention to participate in the FCM, NSTAR requested the evaluation contractors to also compute demand savings using ISO New England's peak demand definitions.

According to NSTAR's peak demand definition, the demand impacts are calculated coincident with the following seasonal coincidence periods:

Summer: June, July, and August, 3pm to 5pm, weekday non-holidays
Winter: December and January, 5pm to 7pm, weekday non-holidays

As per ISO New England's definition, FCM peak demand impacts are calculated coincident with "Demand Resource On-Peak Hours" listed below:

Summer: June, July, and August, 1pm to 5pm, weekday non-holidays
Winter: December and January, 5pm to 7pm, weekday non-holidays

It should be noted that NSTAR considers ten holidays while ISO New England considers only seven holidays.

By the time the decision to include FCM demand savings was taken, traditional savings analysis for a few sites was already conducted. Computing the FCM demand savings required additional efforts, especially for the sites for which the analysis was already completed.

In traditional weather sensitive savings analysis, the months, day of week and hour of day are not available to calculate the accurate demand savings. In such cases, the demand savings were calculated at the extreme temperature occurring during the defined peak demand hour. For non-weather sensitive traditional savings analysis, the demand savings were calculated as the average kW saved during all the defined peak demand hours. These traditional savings analyses do not take into account the actual peak hours, weekday types and holidays.

Table 1 presents a sample bin analysis for site E16. For this site the NSTAR summer demand savings were calculated at the higher temperature bin (92.5 °F) since that was the highest temperature bin (covering 90 °F to 95 °F conditions). The actual highest temperature during the defined peak hours was 90 °F. However, this cannot be captured in the traditional bin analysis. The traditional analysis considers savings for the highest temperature bin 92.5 °F as it represents average ambient conditions between 90 °F to 95 °F instead of 90 °F.

Table 1. Traditional Bin Analysis for Site E16

DB	WB	Op. Hours	Installed System			Baseline System			kWh Savings	kW Savings
			Amps	% Load	kW	BHP	% Eff.	kW		
92.5	69.7	6	35.3	62.0%	25.3	46.0	95.0%	36.1	65	10.8
87.5	70.1	58	34.3	61.2%	24.6	45.9	95.0%	36.0	664	11.4
82.5	68.5	176	33.4	60.5%	23.9	45.8	95.0%	35.9	2,113	12.0
77.5	66.0	232	32.3	59.6%	23.2	45.6	95.0%	35.8	2,945	12.7
72.5	63.3	310	30.8	58.5%	22.1	45.4	94.9%	35.7	4,219	13.6
67.5	59.5	186	28.8	56.7%	20.6	45.2	94.8%	35.6	2,774	14.9
62.5	56.9	229	26.5	54.8%	19.0	44.9	94.7%	35.4	3,747	16.4
57.5	53.8	94	23.7	52.2%	17.0	44.6	94.5%	35.2	1,709	18.2
52.5	49.7	11	19.9	48.3%	14.3	44.1	94.2%	34.9	227	20.6
47.5	43.4	3	13.8	41.2%	9.9	42.8	93.1%	34.3	73	-

Table 2 presents the 8,760 savings analysis for the same site, E16. The table provides sample hours for weekends, a weekday and a holiday. For this analysis, the maximum temperature during defined peak period was appropriately identified as 90 °F and demand savings corresponding to that hour was the actual NSTAR summer demand savings. Similar analysis was conducted for FCM demand savings.

Table 2. Demand Savings Values Comparison

					SF1A						
					Installed System			Pre-Retrofit System			kW Saved
Date	Wd/We	Hr	DB	WB	Amps	% Load	kW	BHP	Eff	kW	
1/1/06	We	1	28.9	23.7	29.15	57%	20.9	45.2	95%	35.6	14.7
1/1/06	We	2	28.9	23.9	29.15	57%	20.9	45.2	95%	35.6	14.7
1/1/06	We	3	28.0	23.5	29.27	57%	21.0	45.3	95%	35.6	14.6
1/1/06	We	4	28.0	23.7	29.27	57%	21.0	45.3	95%	35.6	14.6
1/1/06	We	5	27.0	23.0	29.41	57%	21.1	45.3	95%	35.6	14.5
1/2/06	Holiday	6	26.1	24.0	29.54	57%	21.2	45.3	95%	35.6	14.4
1/2/06	Holiday	7	26.1	23.3	29.54	57%	21.2	45.3	95%	35.6	14.4
1/2/06	Holiday	8	27.0	25.1	29.41	57%	21.1	45.3	95%	35.6	14.5
1/2/06	Holiday	9	28.9	26.7	29.15	57%	20.9	45.2	95%	35.6	14.7
1/2/06	Holiday	10	33.1	29.7	28.68	57%	20.6	45.2	95%	35.5	15.0
1/2/06	Holiday	11	36.0	31.9	28.42	56%	20.4	45.2	95%	35.5	15.1
1/2/06	Holiday	12	35.1	31.4	28.49	56%	20.4	45.2	95%	35.5	15.1
7/20/06	Wd	13	91.9	69.4	34.81	62%	25.0	46.0	95%	36.1	11.1
7/20/06	Wd	14	91.9	68.5	34.81	62%	25.0	46.0	95%	36.1	11.1
7/20/06	Wd	15	91.9	69.0	34.81	62%	25.0	46.0	95%	36.1	11.1
7/20/06	Wd	16	90.0	70.0	34.24	61%	24.6	45.9	95%	36.0	11.5
7/20/06	Wd	17	88.0	69.6	33.66	61%	24.1	45.8	95%	36.0	11.8
7/20/06	Wd	18	84.9	70.4	32.83	60%	23.5	45.7	95%	35.9	12.4
7/20/06	Wd	19	82.0	69.9	32.11	59%	23.0	45.6	95%	35.8	12.8
7/22/06	We	20	64.0	59.0	0.00	0%	0.0	0.0	0%	0.0	0.0
7/22/06	We	21	63.0	59.3	0.00	0%	0.0	0.0	0%	0.0	0.0
7/22/06	We	22	63.0	59.3	0.00	0%	0.0	0.0	0%	0.0	0.0
7/22/06	We	23	63.0	59.9	0.00	0%	0.0	0.0	0%	0.0	0.0
7/22/06	We	24	62.1	59.7	0.00	0%	0.0	0.0	0%	0.0	0.0

The advantage of adopting the 8,760 savings analysis method is that in the future if the demand definitions change, the 8,760-savings load shapes can be used to calculate the savings for given definitions without modifications to the actual savings analysis. The day of the week, hour, and ambient temperature data will be already available in the 8,760 savings analysis.

Sample Results

Table 3 below presents the demand savings summary from the 8,760 method and other traditional methods.

Table 3. Demand Savings Values Comparison

Site ID	Measure	Prior Method				8760 Method			
		Summer Savings		Winter Savings		Summer Savings		Winter Savings	
		NSTAR	FCM	NSTAR	FCM	NSTAR	FCM	NSTAR	FCM
Site ID 02	VFDs	72.2	72.2	74.1	74.1	73.4	73.3	71.2	72.5
Site ID 05	Motors & VFDs	236.7	233.4	240.9	284.8	247.8	247.7	251.9	251.9
Site ID 16	VFDs	176.0	244.3	233.1	337.7	279.4	303.0	294.7	316.3
Site ID 39	VFDs	9.9	10.2	34.1	34.1	14.2	14.2	22.0	22.0
Site ID 41	Motors & VFDs	19.6	31.8	49.6	35.6	22.2	39.7	6.9	22.9

It should be noted that only a handful of site analyses were conducted using both methods. The difference in savings numbers can be attributed to the manner in which the demand savings is calculated and the associated assumptions described in earlier section.

Conclusions

By conducting actual 8,760 savings analyses we can demonstrate that hourly 8,760 savings analyses are more reliable and cost effective way of estimating accurate energy and coincident demand impacts as compared to the traditional bin calculations methods. The hourly 8,760 savings analyses are also more comprehensive than the traditional savings analysis and can be easily configured to reflect the actual site conditions/operating trends. Since the analysis is conducted on an hourly level, accurate coincident peak demand definitions can be applied to obtain reliable demand and energy savings values. The major advantage of an 8,760-hour savings analysis is that in the future if the demand definitions change, the 8,760-savings load shapes can be used to calculate the savings for given definitions without modifications to the actual savings analysis. Impact load shapes, coincidence factors, and peak performance for any conceivable time period may be derived upon request. Of particular interest is the ease and flexibility in calculating the seasonal energy and demand savings for any given demand definition.

References

RLW Analytics, and ERS 2006. *Business & Construction Solutions Programs M&V Final Report*.

ISO New England's web site, http://www.iso-ne.com/markets/othrmkts_data/fcm/index.html

RLW Analytics, and ERS 2006. *Business & Construction Solutions Programs M&V Final Report – Appendix A (site reports)*.