NO BEFORE, ONLY AFTER—THE IMPORTANCE OF ESTABLISHING A BASELINE FOR NEW CONSTRUCTION

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Abstract

Electric utilities are just now pushing into the final frontier of DSM evaluation—commercial new construction programs. Unlike retrofit programs where there is a clear before and after, the determination of the before (no DSM or non-participant case) is less straightforward in new construction. This paper examines the importance of accurately determining baseline construction practices when evaluating the performance of new construction DSM programs. In addition, the paper examines the relative strengths and weaknesses of several approaches to establishing new construction baselines.

Savings from new construction DSM measures imply that the baseline practice is less efficient. The question is: exactly how efficient is the baseline? Unless baseline practices can be accurately determined across all major building subsystems, a correct assessment of energy and demand savings is not possible. Many approaches exist that can assist the utility planner in establishing new construction baselines. These include, but are not limited to:

- *Examination of state and local building codes.*
- *Review of national standards, ASHRAE 90.1, and the Department of Energy's new commercial building standards.*
- *Discussions with local design professionals and code officials.*
- *On-site surveys.*

Actual experiences with each of these approaches are cited to illustrate potential advantages and disadvantages of each method.

Introduction

In recent years, utilities have increased the resources directed at the development and implementation of DSM programs for commercial new construction. By providing incentives for the incorporation of energy-efficient practices, utilities are able to:

- Purchase DSM resources at a lower cost relative to retrofit measures. New construction incentives are typically capped at incremental cost versus some portion or all of full, installed measure cost for retrofit applications. For some measures, such as HVAC equipment improvements, the retrofit applications are not cost-effective, while the new construction installations are.
- Address the building as an integrated system. Improvements in lighting systems, in theory, can result in downsizing of the building's HVAC system. In turn, this can reduce the costs associated with the lighting system improvements.
- Overcome initial resistance to the introduction of new technologies. Once a design professional has successfully incorporated a DSM technology as a result of a utility program, that measure is more likely to be incorporated in future buildings.

While new construction programs offer utilities a number of distinct advantages relative to the more common retrofit programs, new construction programs also present the utility planner with a number of potential problems not common to retrofit programs. One of the potentially most important is the establishment of a baseline of current new construction practices for:

- Determining minimum eligibility criteria for program measures.
- Determining program savings resulting from the installation of energy efficient measures.

This paper focuses on the latter point, establishing a baseline to determine program savings.

In retrofit programs, the baseline is usually a known quantity, reflecting established practices and equipment prior to replacement with more efficient measures. For example, in lighting programs the pre-retrofit lamp/ballast combination can be characterized or the building's lighting power density (w/ft^2) calculated. In a new construction program, neither of these parameters is typically known, as the goal of a new construction DSM program is to intervene as early as possible in the design process, prior to the establishment of a baseline in a participating facility.

The question, then, is how can a baseline be established for new construction that will allow program savings to be determined with some level of accuracy? Effectively, the utility planner must characterize baseline practices in nonparticipants. This paper will examine a number of options to perform this baseline determination, each with distinct advantages and disadvantages. Further, what might be appropriate for one utility's situation may not be appropriate for another. Typical tradeoffs center on cost versus degree of accuracy and utility territory specificity.

Examination of State and Local Building Codes

Many state building codes contain provisions relating to energy efficiency in new construction. Use of these code requirements to establish a new construction baseline is a low-cost effort requiring minimal utility staff time. However, the usefulness of state building codes to define current construction practices is limited by a number of factors, including:

- Building code requirements are often set as minimum standards; they are not necessarily set to reflect current practice. A few exceptions to this practice exist, such as sections of the California, Massachusetts, Oregon, and Washington state codes.

- Energy conservation sections of state codes are updated infrequently. New York revised its commercial energy code this year. Its last major update was in 1979. The energy conservation sections of the Massachusetts State Building Code were revised in 1988; the last significant revision was in 1979. Many state codes have not been revised in over a decade and reflect, at best, current practice in the late 1970s.

- Many state building energy codes are based in whole, or in part, on national model codes such as the Council of American Building Officials (CABO) Model Energy Code. The technical requirements in these model codes closely follow those developed as part of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standard-setting procedures. Many state or local codes based in whole or in part on national model codes reference earlier versions of the model codes. The national model codes are typically updated on a three year-cycle, though supplements may be incorporated more frequently. These earlier model codes, in turn, are based on the now superseded ASHRAE 90A-1980 energy standards, rather than the more recent ASHRAE 90.1 standards. Further, those national model codes that have recently incorporated ASHRAE 90.1 have only done so by reference and only as an option to the outdated 90A-1980 standards. In addition to the inherent limitations of even the current ASHRAE standards, as discussed below, adoption of model codes fails to reflect any local differences in design or construction practices.

Review of National Standards

At present, two documents can be considered national standards for energy efficient commercial construction: ASHRAE's Standard 90.1, Energy Efficient Design of New Buildings Except Low Rise Residential Buildings and the Department of Energy's (DOE) Energy Conservation Voluntary Performance Standards for Commercial and Multifamily High Rise Residential Buildings; Mandatory for New Federal Buildings. The two documents are nearly identical in their technical requirements as a result of their common parentage extending back over a decade to a joint ASHRAE-DOE research project. A few significant differences between these two documents exist and include:

- Adoption of more stringent HVAC equipment standards by DOE in 1989. Similar equipment efficiencies are not effective in ASHRAE 90.1 until January 1, 1992.

- Inclusion of a second, more stringent set of lighting power allowances in the DOE standards. These criteria are effective in 1993. ASHRAE 90.1 has no second tier of lighting standards.

- ASHRAE is a national consensus standard and, as such, had to go through a development and review process defined by the American National Standards Institute (ANSI). The DOE document, while subject to public review and comment, is not a national consensus standard. As a consensus standard, the ASHRAE requirements, rather than those of DOE, typically have been adopted by the national model code groups.

Comments on the use of national standards as a baseline for new construction evaluation are restricted to ASHRAE 90.1 and, with a few exceptions, apply to the DOE standards, also.

As with the use of state building codes, using ASHRAE 90.1 as an evaluation baseline is a low-cost option. As a means to define a commercial new construction baseline, ASHRAE 90.1 has benefits relative to most, but not necessarily all, state or local building codes. These include:

- ***Timeliness.*** ASHRAE 90.1 was adopted in 1989 and is more current than most state energy codes.
- ***A more thorough understanding of building operations.*** Many state codes have thermal envelope requirements that are driven by heating, rather than cooling, building needs. ASHRAE 90.1 gives greater consideration to commercial cooling loads and varies envelope requirements as a function of climate, internal loads, and a number of other factors.
- ***Disaggregation of lighting power density requirements by building type.*** ASHRAE 90.1 provides prescriptive maximum lighting power densities (w/ft^2) for 13 building types. These numbers provide an easy-to-use basis for determining lighting energy usage and savings. Comments from lighting designers are that these numbers reflect current or better than current practice. This view is further supported by limited field observation (Ref. 1). Note that ASHRAE 90.1 has two lighting compliance options: a prescriptive path and a performance path. The performance path, for most buildings, is considerably less stringent.

Unfortunately, a number of factors diminish the usefulness of ASHRAE 90.1 as a means to establish baseline practices in new commercial construction. As a national standard, 90.1 will not reflect specific local design or construction practices. Also, certain sections within 90.1 are not easily used for evaluation purposes. The most notable of these is the building envelope criteria. ASHRAE 90.1 does not provide a simple overall U-value or overall thermal transfer value (OTTV) calculation criteria. Rather, several building parameters are used to determine the maximum allowable percent of fenestration (prescriptive approach) or whether the facility as defined meets a building/climate-specific set of heating and cooling budgets (computer-based performance approach). The parameters required include:

- Internal load range
- Glazing U-value
- Glazing shading coefficient
- Extent of window overhang
- The presence of perimeter daylighting
- Facility heating degree days (base 50) and cooling degree days (base 65).

The values can be used with a look-up table (prescription approach) or as inputs to a computer compliance model (performance approach). If computer compliance is used, then these values must be entered for up to eight exterior building orientations. For building envelopes, ASHRAE has traded simplicity for design flexibility and a more realistic determination of energy flows through the thermal envelope.

Unfortunately, neither approach for determining envelope compliance readily lends itself to the establishment of a new construction baseline. While both approaches specify maximum U-values for opaque wall and roof sections, there are no single values specified for glazing U-value or shading coefficient. The allowable values for these parameters will vary, based on the values of the other required envelope parameters. Both envelope compliance approaches are interactive and, as such, are of limited use in establishing minimum baseline practices.

Possibly the greatest limitation of using 90.1 as a baseline of current practice in new construction is that the efficiency requirements in a number of areas do not reflect current practice. In many cases, the 90.1 standards specify efficiencies less than current practice. To some extent, this is to be expected. Historically, energy conservation codes and standards have been designed to remove the least efficient models and practices from the market, not to codify standard practice. In some areas, the new ASHRAE standards are at, or exceed, current practice (prescriptive lighting requirements and building envelope) while in others the standards tend to fall short of current practice (performance lighting requirements and HVAC equipment requirements). A further explanation for ASHRAE 90.1's failure to reflect current practice is that, while the standard became effective in 1989, the process to develop and review the three interim draft standards took over seven years. It is not clear that during this timeframe all efficiency requirements were subjected to periodic review. As a result, the market has significantly surpassed a number of 90.1's technical requirements.

Examples of 90.1's failure to reflect current market conditions can be readily found in the HVAC equipment requirements. For example:

- Single-phase, unitary cooling equipment, ≤ 65,000 Btuh cooling capacity—ASHRAE 90.1P minimum performance is 8.9 SEER. In 1990, the Air Conditioning and Refrigeration Institute (ARI) estimated that only 20% of shipments had SEERs below 9 (Ref. 2).

- Water-cooled, water chilling systems, ≥ 300 tons—ASHRAE 90.1P minimum performance is a COP of 4.6 (15.7 EER or 0.76 kW/ton). No distinction is made of chiller type. Our estimate for typical centrifugal chillers specified in this size is a COP range of 5.2 to 6.1 (0.58 to 0.68 kW/ton).

- Water source heat pumps ≤ 65,000 Btuh cooling capacity—ASHRAE 90.1 minimum performance is 9.0 EER. Review of ARI's listing of over 300 water source heat pumps did not find a single model with an EER of 9.0 or less (Ref. 3).

Interviews with Design Professionals

Interviews with design professionals hold the promise of obtaining current, accurate information on local design practices. Unfortunately, our experience to date has shown that this approach produces varied results at best. This method appears to work best when the questions are specific, *e.g.*, lighting design in office buildings. Even when questions are relatively specific, the responses may not be. In particular, efforts to collect data on glazing and HVAC equipment often fail to elicit numerical responses. Surprisingly, a significant number of individuals responsible for specifying HVAC equipment were not able to provide typical equipment efficiencies. In these instances, the response was often that the equipment met code.

Table 1. Massachusetts Joint Utility New Construction Project : Fluorescent Lamp Inventory—Office Building

Lamp Type	Fixture Group	Ballast Type	Fixture Code	Watts	% Watts	Fixtures	% Fixtures
STD	F40T12	STD	402	1,504	0.3	16	0.4
		STD	403	151	0.0	1	0.0
		STD	404	6,392	1.3	34	0.9
		EEMAG	407	20,296	4.1	236	6.0
		EEMAG	408	132,464	27.1	974	24.7
		EEMAG	409	1,376	0.3	8	0.2
	F96T12	STD	601	200	0.0	2	0.1
		EEMAG	607	2,844	0.6	18	0.5
	F96T12/HO	STD	631	135	0.0	1	0.0
		STD	632	8,224	1.7	32	0.8
Subtotal, STD Lamp Type				173,586	35.5	1,322	33.5
EE	F40T12	STD	417	1,760	0.4	22	0.6
		EEMAG	421	320	0.1	8	0.2
		EEMAG	422	1,820	0.4	26	0.7
		EEMAG	423	44,440	9.1	404	10.2
		EEMAG	424	51,520	10.5	368	9.3
Subtotal, EE Lamp Type				99,860	20.4	828	21.0
T8	F32T8	ELIG	449	216,000	44.1	1,800	45.6
Total, All Lamps				489,446	100.0	3,950	100.0

On-site Surveys

On-site surveys provide a means to collect detailed equipment inventories from which a representative baseline can be constructed. Not surprisingly, this option is by far the most labor- and time-intensive of the methods discussed. Based on recent studies performed in Massachusetts and Connecticut, the cost for a comprehensive study of new construction practices can vary from $800-$1,800 per observation, depending on the number of facilities surveyed, their size, the end uses addressed, their geographic proximity, and so on.

While a new construction study based on on-site data collection is a relatively expensive option, it is the only approach discussed that can provide a utility with a reasonably accurate estimation of current construction practices specific to the utility's service territory. Information obtained from the recent Connecticut and Massachusetts studies includes:

- Average lighting power densities on a building type level.
- Average lighting power densities on a space type level, *e.g.*, private office, hallway, conference room.
- Detailed lighting equipment inventories at the building type level, by general source (incandescent, fluorescent), lamp type (40 watt T-12, 34 watt, T-12, T-8) and ballast type (energy savings magnetic, electronic). Table 1 provides an example of the detail possible in terms of characterizing installed fluorescent lighting systems.
- Average roof and wall U-values, by building type.
- Cooling and heating equipment efficiencies by equipment and building type.
- Percent of installed cooling capacity with economizers.
- Installed linear feet of refrigeration cases by case type.
- Refrigeration case defrost type.

This approach, while generating a wealth of data, is not without problems. Typical problems encountered are of two general types: (1) general program design questions and (2) on-site data collection limitations. Issues related to general program design center on defining the new construction population. For a utility covering a large number of cities or towns, or for a study covering several utility service territories, how can the new construction population be identified? To date, we have attempted two approaches.

1. ***Utility new account data.*** Experience with one of our studies showed that the majority of new accounts were neither new facilities or additions to existing facilities.

2. ***F.W. Dodge data (or similar construction start tracking data).*** F.W. Dodge tracks new construction starts, as well as major renovation and remodeling work. Unfortunately, the Dodge data are not complete in their coverage. Additionally, data on buildings below a certain size can be obtained only as hard copy. Data on larger buildings can be provided on diskette. For our Massachusetts joint utility study of four service territories, these data cost $7,000. For the Massachusetts study, Dodge supplied us with information on new construction activity for over 1,400 facilities. These data covered 30 different building types over a 14-month time frame. Data provided for each facility varied, but usually included all or some of the following:

   - Facility name and address
   - Dollar value of construction activity
   - Developer and/or contractor name, address, and phone number
   - Architect name, address, and phone number
   - Engineer name, address, and phone number

3. Provision of contact names and phone numbers facilitated project solicitation. Additionally, the architect and engineer data were used to schedule post-survey design professional interviews.

Even when the newly built facilities are identified, one must question how current the designs reflected in the new buildings are. Preliminary plans and equipment specifications can be made several years prior to a building's completion. Surveys of buildings representing three- to four-year old designs may underestimate the current saturation of such technologies as T-8 lighting systems, compact fluorescents, and electronic ballasts. The use of post-survey professional interviews in our Massachusetts study allowed us to verify whether observed practices were still representative of the firms' current design and construction practices.

While on-site data collection can provide mind-numbing detail on lighting inventories, a number of equipment/building parameters that are often difficult to collect:

- Glazing U-values and shading coefficients
- Heating and cooling equipment efficiencies
- Refrigeration compressor and case fan data

These data collection gaps can be filled, to some extent, by post-survey phone follow-ups with the facilities' architects and engineers. Additionally, recording of HVAC equipment model numbers allows manufacturers' catalogs and the ARI equipment directories to be referenced to determine equipment efficiencies.

One final comment is required regarding the use of on-site surveys to quantify new construction practices. It has been hypothesized that equipment loadings for certain end uses will increase over time following building occupancy. In particular, lighting levels are suspected to increase as tenants occupy a space and task lighting appears. One solution to this is to restrict surveys to those buildings with a minimum number of months of occupancy. This, however, can be done only at the expense of further aging the building's design and construction practices. Interestingly, a 1989 study for Seattle City Light found that task lighting comprised less than 1% of occupied building electricity use. (Ref. 4)

Summary

While several options are available to the utility planner to devise a new construction baseline, each one has specific advantages and disadvantages. For many utilities, local or state building codes are out of date. National efficiency standards, specifically ASHRAE 90.1, represent an improvement over many state codes. However, the degree to which 90.1 represents current construction practice seems to vary to some extent by end use. Further, for building envelope, the new 90.1 compliance approaches do not lend themselves to developing easily defined baselines.

Interviews with design professionals hold the promise of obtaining both current and utility-specific data. Unfortunately, responses tend to be less quantitative then expected. Finally, on-site surveys offer the greatest degree of analytical rigor and definition. Unfortunately, these come at a significant cost premium.

References

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