MEASURING NEW CONSTRUCTION BASELINE BUILDING PRACTICES FOR COMMERCIAL FACILITIES IN FPL SERVICE TERRITORY

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ABSTRACT

Florida Power and Light (FPL) has recently completed the first phase of its Commercial/Industrial (C/I) New Construction Research project, a project which culminates in the phase 4 design of a C/I sector new construction pilot program. The first phase of this project included an assessment of baseline building practices in FPL service territory using submitted Florida Energy Efficiency Code (the Code) compliance documents. The results of this effort suggest that the Code (which is ASHRAE 90.1 compliant) may overstate the efficiency level of new buildings.

Using the Method A compliance approach and the State of Florida FLA/COM software, the assessment of Code-based baseline building practices suggests that on average buildings are nearly twice as efficient as is required by the Code.

In the second and third phase of this research effort, engineering impact models are used to quantify the impact potential of various energy conservation measures (ECMs). The baseline building practices are used to define the energy usage of typical buildings in the absence of an FPL new construction program. During phase 3 field research, the baseline attributes found in the Code documents are verified based upon as-built specifications collected during on-site audit activities.

The phase 4 program design will make recommendations regarding a program format that will maximize the energy benefits of an FPL pilot program in a cost-effective manner. This design will rely upon an accurate measurement of ECM targets, which can only be achieved given a thorough assessment of baseline building practices.

Introduction

Utility DSM/market transformation programs must be cost-effective, and must address a utility's mandate (energy savings, peak power demand reduction, or both). When designing a new DSM/market transformation program, utilities often use "current" market information, then evaluate the program's benefits after implementation. As "current" market information does not always cover the entire range of issues affecting the performance of a program, post-implementation evaluations often uncover program design problems that diminish cost-effectiveness. Market characterization prior to program design is therefore crucial for making informed design decisions.

Baseline assessment is composed of the following steps:

1) **Assemble Energy Code Compliance Documents.** Collect submitted energy code compliance documents that describe the physical features of a new building, the building's mechanical cooling, heating and ventilation systems, the building's indoor and outdoor lighting systems/specifications, the water heating system, and other miscellaneous equipment such as motors. Create a database of detailed new building features, measurements and specifications.

2) **Assemble Alternate Building Feature Data.** Where the code compliance documents fail to provide adequate data in support of new construction baselines, alternate data are used. These data come from internal FPL sources, such as system-wide appliance saturation surveys, and data available through federal agencies like the Energy Information Administration (the Commercial Buildings Energy Consumption Survey, for example).
3) **Generate Baseline Building Prototypes.** Prototype new building features and mechanical systems are compiled using the code compliance database and other alternate sources for building features.
4) **Collect On-Site Audit Data.** On-site audit data are collected in order to verify the code compliance findings. A nested sample design (consisting of buildings found within the compliance database) is used to ensure a direct comparison of submitted code features and systems (as-designed) with those observed in the field (as-built).
5) **Identify and Quantify Compliance Database Accuracy Issues.** Detailed comparisons are then drawn between the as-designed and as-built buildings, yielding methods used to compensate for code compliance deficiencies in the general new construction population.
6) **Adjust Baseline Building Prototypes.** Based on the database accuracy issues uncovered, adjustments are made to the code compliance-based baseline prototypes to account for as-built practices observed in the new construction market.

The end result is baseline prototypes that accurately reflect the current construction practices in commercial buildings in FPL service territory. The use of these adjusted prototypes ensures that the assessment of energy conservation measure (ECM) demand and energy impacts are based upon an appropriate baseline energy use profile.

Although the next steps of this project are described towards the end of this paper (culminating in the design of a commercial new construction program), the focus is on baseline development and adjustment.

Baseline Development from Code Compliance Documents

Baseline building prototype development began with the collection and assessment of new building features using submitted Florida Energy Efficiency Code (the Code) compliance documents, generated using FLA/COM software. The Code governs building characteristics that affect energy usage for several important end uses, including cooling, heating, ventilation, indoor lighting, outdoor lighting and water heating. For those end uses, Code compliance documents are particularly important to the initial baseline characterization.

The Code does not govern certain end uses that are most important in specific business types. For example, the refrigeration end-use is largely applicable to the grocery, retail and warehouse business types, and the cooking end-use is somewhat confined to the restaurant business type. In those instances, other data sources that are relevant to FPL service territory where possible, or if necessary, otherwise, are integrated in the development of baseline end-use characterization models.

In addition to each end-use, the baseline models are further segmented into business type because the end-use contribution to a customer's utility bill varies significantly with the facility function. FPL selected nine business type segments for analysis: small office, large office, restaurant, retail, grocery, college/university, school, hotel/motel, and hospitals.

Primary Data Sources

FLA/COM compliance data were obtained from two sources, and subsequently used to derive the initial baseline characterizations: FLA/COM input files and hard copy printed compliance forms. FLA/COM is the software that is used in the state of Florida to assess building design compliance with the Florida Energy Efficiency Code.

FLA/COM input files. The electronic files that describe building envelope and mechanical features were obtained from compliance contractors and others who have used FLA/COM, either for buildings of their own design or for buildings designed by other firms. QC obtained lists of buyers of the FLA/COM software from the Department of Community Affairs. Using this list, potential contacts were identified by the name of the company (e.g., Computerized Energy Management; Compliance Consultants, Inc.) A search was then conducted for telephone numbers using an internet yellow pages listing, and firms were contacted by phone.

Firms who reported using the FLA/COM software to verify compliance with the Florida Energy Code were asked if they would supply us with electronic copies of the input files for as many commercial buildings as they had available. In all, over 1200 files were received and subsequently used for baseline development.

The data obtained were self-selected. In order to correct for potential self-selection bias, a sample of hard copy filings were also obtained using random selection methods (as discussed next). Baseline assessment activities will include a comparison between the randomly collected compliance filings and the electronic FLA/COM input files, and, if necessary, an adjustment will be made to the baseline models.

Hard Copy FLA/COM Compliance Filings. Hard copy Florida Energy Efficiency Code compliance forms were obtained during a one-week trip to the Department of Community Affairs (DCA) Tallahassee facility. Our goal was to obtain as many hard copy compliance documents for commercial facilities in FPL service territory as we could in our one-week time frame (including time to make copies and return the forms to their original location.) Our target was a total of 500 forms: 150 from the North DCA climate (climate zones 1,2 and 3), 150 from the Central DCA climate (climate zones 4,5 and 6), and 200 from the South DCA climate (climate zones 7 and 8).

Before initiating the collection of hard copy data, FPL's customer information system (CIS) was used to study the frequency of new construction within FPL service territory, and to identify cities with a high incidence of new construction, which in-turn was mapped back to permitting offices in most instances. This was used to identify several high priority permitting offices, by climate zone.

- NORTH: St. Augustine, St. Augustine Beach, Lake City, Palatka, Live Oak, MacClenny, Fernandina, Bunnell, and Callahan.
- CENTRAL: Sarasota, Bradenton, Melbourne (and Melbourne Beach), Sanford, Cocoa (and Cocoa Beach), Daytona Beach, Ormond Beach, Rockledge, Titusville, and other permitting offices in the Indian River area.
- SOUTH: Miami, Miami Beach, Hialeah, Naples, West Palm Beach, Ft. Lauderdale, Boca Raton, and Boynton Beach.

The form collection effort focused on the most recent submissions and the permitting office/jurisdiction number. Older records were drawn if we had difficulty filling the sample. Within each climate, records were obtained from at least four different permitting offices. Forms were recorded as drawn, by FLA/COM building type, size, and climate zone.

Documents collected represented only new buildings (additions and retrofits were excluded from the sample frame), submitted under either the 1993 code or the 1997 code. Residential compliance forms were also excluded. The forms collected were those generated using the DCA FLA/COM software, either the 1993 or 1997 version. In particular form 400's were collected that were generated using the Method A whole building performance approach. Data on methods B, C and D (component performance, limited and special use buildings prescriptive, and renovations and systems prescriptive method) were not collected.

It should be noted that permitting offices are only required to file the Florida Energy Code compliance form with the DCA – not the detailed FLA/COM output. Since our goal was to collect the more complete FLA/COM information required to characterize the new construction market, we focused our efforts on gathering the forms that included the detailed output.

The compliance form itself, however, is also a source of each building's FLA/COM-derived energy usage as a percentage of the Energy Code "budget" of 100, as well as of the size and type of buildings constructed in each climate zone. As shown in Figure 1, these submitted energy code documents suggest that builders are already submitting buildings that substantially exceed the energy code requirements. Another way to interpret this result, however, is that the energy code requirements, though ASHRAE 90.1 compliant, do not lead to significant energy efficiency improvements in the commercial new construction market.

While the State of Florida has adopted Energy Code requirements that are ASHRAE 90.1 compliant, it appears that the ASHRAE code is not particularly functional or effective, as new buildings are surpassing the code requirements with little evidence of having moved the market towards more efficient practices. In this way, the code serves little purpose, and acts to minimize the importance of energy efficiency in the State of Florida. It appears that the market already supports building practices that exceed the ASHRAE requirements, and the State of Florida should consider improvements to the Code that will spur market movement.

The bell shaped curve in Figure 1 further implies that the market is unregulated with respect to code compliance. In other studies, including FPL residential new construction research, the code performance curve is extremely right hand skewed, implying that the building designs are just barely passing code (and that designers must often upgrade the building envelope or mechanical systems in order to meet "more stringent" code requirements).

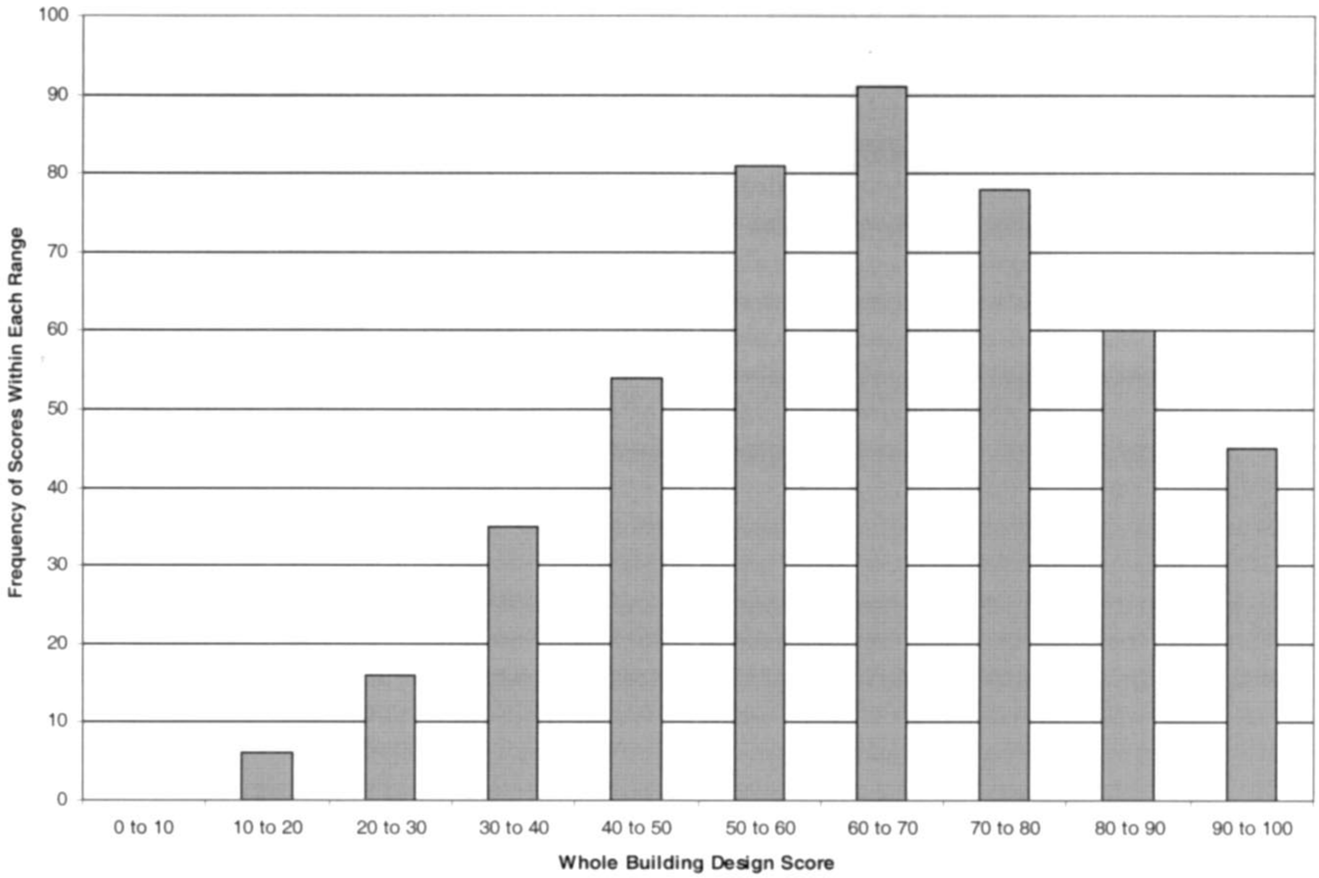

Figure 1. FLA/COM Whole Building (Method A) Compliance Scores

Initial Baseline Development

While the use of the above FLA/COM data proved invaluable in the initial Phase 1 development of baseline, several weaknesses were encountered in these data. The methods used to correct for those deficiencies are described below.

FLA/COM Issues and Concerns. Although we were able to obtain a significant number of detailed records regarding current design practices in the commercial new construction market in FPL's territory, there are several areas of building design where the FLA/COM data, by itself, are insufficient in detail.

- While overall lighting densities (in watts per square foot) are specified by the Florida Energy Code and included in FLA/COM, there are no data provided on lighting levels or the technologies specified. One cannot tell, for example, whether current new design/construction practice is to specify and install T8 fluorescent bulbs and electronic ballasts or 34w energy saver T12s with hybrid or electronic ballasts.
- Major end uses for specific building types (e.g., cooking for restaurants; refrigeration for groceries) are not covered at all by the Code or by FLA/COM. Other examples of significant energy efficiency technologies not included in the files are data on HVAC economizers, programmable thermostats/EMSs, and thermal energy storage systems.
- No information is available to indicate whether a given building is to be formally commissioned.

- It is sometimes not possible to tell from the FLA/COM data precisely what type of building is being submitted, since the building types specified by the Code (and FLA/COM) do not always map to the building types of interest for this project.
- Similarly, it was difficult to link the FLA/COM filings to FPL billing data for future analysis tasks. Some of the electronic records, in particular, have had owner names deleted (for reasons of confidentiality), and street addresses may be unknown, left blank, or subject to change before construction is completed.

Solutions to the Above Challenges. We addressed the above shortcomings of the FLA/COM data by supplementing it with data from other sources. Those data sources are identified in Table 1 which includes the following:

- Surveys with architecture and engineering (A&E) firms were used to gather data regarding lighting technologies that are used in current design.
- An attempt was made to identify A&E firms who specialize in supermarket design, to gather data on current practice for the distinctive characteristics (e.g., refrigeration) of this business type, that are not covered by FLA/COM.
- Data from an FPL Commercial Appliance Saturation Survey was used to support data regarding the characteristics (and energy usage and load shapes) of business types of interest for this study.
- Commercial Buildings Energy Consumption Survey (CBECS) data from the DOE's Energy Information Administration were also obtained, and served to fill gaps in the baseline characteristics extracted from FLA/COM and saturation data sources. This database provides information on the building energy consumption/intensity, building envelope, HVAC systems and conservation features, water heating energy sources, cooking energy sources, production equipment, and lighting systems.

Table 1. Data Sources for Developing Baseline Prototypes

Baseline Prototype Feature	Baseline Prototype Characteristic	Data Sources: FLA/COM Input Files	Data Sources: FPL Commercial Appliance Saturation Survey	Data Sources: Trade Ally Surveys	Data Sources: Other Industry Data
Building Envelope	Conditioned Floor	●	◒	○	○
	Roof	●	◒	○	○
	Walls	●	◒	○	○
	Windows	●	◒	○	○
	Overhangs	●	○	○	○
HVAC Mechanical Systems	Air Conditioning	●	◒	○	○
	Heating	●	◒	○	○
	Ventilation	●	◒	○	○
Lighting	Indoor	◒	◒	●	◒
	Outdoor	●	◒	○	○
Other End Uses	Water Heating	●	◒	○	○
	Refrigeration	○	●	◒	○
	Cooking	○	●	○	○
	Office Equipment	○	●	○	○
	Other	○	●	○	○

KEY	
Primary Data Source	●
Secondary Data Source	◒
Not Used	○

Data from all the above sources were integrated to develop building-type-specific prototypes to be used for analysis of energy-efficient measures and practices. In addition, during phase 3 field research, the baseline attributes found in the Code documents are to be verified based upon as-built specifications collected during on-site audit activities. Although the original work scope did not stress the importance of field-measured baseline verification, the scope of the project for field activities was modified midstream in the project, shifting resources from end-use metering (for model calibration) to baseline assessment. This shift in resources is consistent with FPL evaluation activities that are being conducted for its many retrofit programs, which all seek to quantify baseline efficiency practices in an evolving energy market.

Continuing Baseline Development

The assessment of the Code indicates that the Code is not rigorous, allowing most buildings to pass code with minimal consideration of energy efficient measures and practices. This suggests that there is much room for improvement in the ASHRAE 90.1-based Code.

- As shown earlier, the average whole building Method A design score is 65, while the qualifying score is 100. This would suggest that the current practice in Florida is already 35 percent better than FLA/COM requirements. However, a closer look at these baseline data suggests that these scores are attained within a building population that has base-level cooling equipment efficiency levels, single-pane clear glass, R-10 ceiling insulation, electric strip heat heating systems, and an allowed indoor lighting power density of about 2.0 Watts/sqft. Further investigation, through Phase 3 on-site verification, is needed to assess the accuracy of these FLA/COM-based findings.

- A discussion is in order surrounding the implications, from an efficiency point of view, of the above listed FLA/COM findings. The cooling equipment efficiency levels for small unitary cooling equipment are on average, for example, just 10-11 SEER, or barely exceeding the National Appliance Energy Conservation Act standards of 9.7 for packaged systems and 10 for split systems. Furthermore, single-pane glass, R-10 ceiling insulation and electric strip heating systems, while allowable in the mild FPL heating climate, are not exemplary technology choices from an energy efficiency standpoint. Lastly, the 2.0 Watts/sqft indoor lighting power density is only half as efficient as best practice in the industry, where state-of-the-art utility programs mandate levels of 1.2 Watts/sqft and customer installations have achieved levels as low as 0.7 Watts/sqft.
- The FLA/COM software may often be misused. There are inadequate internal safety checks performed by FLA/COM during data entry, leading to inaccurately modeled buildings. The FLA/COM model and data will be assessed in more detail in Phase 2. Checking/validation of FLA/COM simulations could be a valuable feature of an FPL commercial new construction program.
- Code enforcement, through field inspections, is another program design feature to be considered. There is reason to believe that some portion of building inspectors do not adequately check for proper code compliance.

Ongoing Analysis Beyond Baseline

The remaining research activities to be completed by QC in support of the design of a commercial new construction program includes: an assessment of the builder market, an evaluation of the accuracy of State Code enforcement and compliance, and quantifying the impacts and costs associated with energy efficiency measures.

Next Steps in ECM Assessment

End-use models, based on the adjusted prototypes, are used to estimate hourly energy usage of new buildings in FPL service territory. The resulting baseline profiles are further calibrated using whole-premise interval data collected from a nested sample (from within the on-site audit sample) of buildings and other internal FPL sources. This calibration of the end-use models ensures an appropriate assessment of hourly energy use by end-use and building type.

With baseline modeling completed, ECM energy use effects are simulated, yielding hourly demand impact profiles. Energy usage effects (i.e., annual) are estimated using summed differences between these profiles, while demand effects are estimated using selected hourly peak day results.

In addition to the estimates of impact, ECM costs are also assessed, along with the cost effectiveness of the ECMs that could potentially be installed through the program. For example, ECM costs per summer demand reduction is a good indicator of ECM cost effectiveness. By ranking measures in terms of both the impacts achieved and also by cost-effectiveness indicators, the best program ECM choices are identified.

Next Steps in the FPL Program Design

In the second and third phase of this research effort, engineering impact models are used to quantify the impact potential of various energy conservation measures (ECMs). The baseline building practices are used to define the energy usage of typical buildings in the absence of an FPL new construction program. If not corrected, inaccuracies in the submitted code-based baseline would haphazardly affect the accuracy of phase 2 and 3 cost-effectiveness assessments for candidate ECMs. Impact and cost-effectiveness results are used, along with the Phase I assessment of state-of-the-art new construction programs, to assess various program designs.

The phase 4 program design will make recommendations regarding a program format that will maximize the energy benefits of an FPL pilot program in a cost-effective manner. This design will rely upon an accurate measurement of ECM targets, which can only be achieved given a thorough assessment of baseline building practices.

Interviews conducted with players in the construction market are used to assess the receptivity of the suggested program design. Phase 4 culminates in the selection of an appropriate and viable new construction program.

Conclusions

To properly design and test the cost-effectiveness of a commercial new construction program, it is essential that accurate (calibrated simulation model) estimates of energy and demand savings are used. Accurate baseline models are a prerequisite for that objective. The data collection and analysis methods described in this paper will ensure that these objectives are achieved. Similar research projects, conducted in other utilities' service territories, would lead to informed decisions in the design of new programs.