Put the Horse Before the Cart – Baseline Characterization in Support of Utility Program Design

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ABSTRACT

This paper describes the research activities currently underway to support design recommendations for a commercial new construction program in Florida. The research places emphasis on evaluating the accuracy of State Code enforcement and compliance, and establishing business type-specific baselines for building construction and the most important end uses. Using the established baselines, candidate energy efficiency measures are selected, their impacts are quantified, then ranked by cost-effectiveness. The final phase of this research will recommend a program format that maximizes energy benefits in a cost-effective manner.

The paper concludes that the Florida State Code is not a reliable baseline for program design and that the Code should be upgraded to reflect current design and construction 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 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 reveal program design problems that diminish its cost-effectiveness. Market baseline characterization prior to program design is therefore crucial for making informed design decisions.

Florida Power and Light (FPL) has recently completed the first two phases of its Commercial/Industrial (C/I) New Construction Research project. The first phase included an assessment of baseline building practices in FPL service territory using submitted Florida Energy Efficiency Code (the Code) compliance documents and on-site audits of 100 new construction sites. The second phase consisted of selecting candidate energy conservation measures (ECMs), quantifying their impacts and estimating their payback, then ranking them using a number of program design criteria. Phase three of the project will rely on market acceptance information to design program elements consisting of the highest-ranking ECMs, then will quantify their impacts and evaluate their cost-effectiveness. The project will culminate with recommendations for a program format that maximizes energy benefits in a cost-effective manner.

FPL put significant effort into defining the commercial new construction baseline as the first step in program design. This paper presents the research activities that supported the design

of the commercial new construction program, and the direct benefits of this research on program cost-effectiveness.

FPL Commercial New Construction Baseline Characterization

The purpose of FPL's commercial new construction baseline characterization is to produce business type-specific prototypes that accurately reflect the current construction practices in commercial buildings in FPL service territory. The use of these prototypes in the subsequent assessment of energy conservation measure (ECM) demand and energy impacts ensures that the impact evaluation is based upon appropriate baseline energy use profiles.

As summarized in Table 1, the FPL commercial new construction baseline characterization relies on information from several different sources.

Table 1. Data Sources for Developing Baseline Prototypes

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

KEY
Primary Data Source ●
Secondary Data Source ◒

The Florida Energy Efficiency Code (the Code) governs building characteristics that affect energy usage for cooling, heating, ventilation, indoor lighting, outdoor lighting and water heating. Code compliance documents are especially important in assessing new construction practices regarding these end uses.

The Code does not govern certain end uses that are most important in specific business types. For example, the refrigeration end use is applicable mostly 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 were integrated in the development of baseline end use characterization models.

Because the end use contribution to a customer's utility bill varies significantly with the facility function, the baseline models were segmented into business types. For analysis, FPL selected ten business segments representing 60% of annual additions to building stock: small and large office (10% each), restaurant (3%), small and large retail (7% each), grocery (3%), school (6%), college/university (3%), hospital (4%), and hotel/motel (7%).

Baseline Development from Code Compliance Documents

In the absence of baseline research, the Code would be considered representative of new construction practices and would constitute the primary source of information for developing baseline prototypes. An assessment of Code compliance documents reveals the ease with which new buildings meet Code requirements, and identifies the instances in which energy efficiency measures are used to exceed Code requirements.

In Florida, Code compliance is verified using the FLA/COM software. For baseline assessment, FLA/COM compliance data were obtained from two sources: electronic input files and hard-copy printed compliance forms.

FLA/COM electronic input files. The Department of Community Affairs supplied a list of buyers of the FLA/COM software. Using this list, potential contacts were identified by the name of the company (e.g., Computerized Energy Management, Compliance Consultants, Inc.), a search was conducted for telephone numbers, and firms were contacted by phone. Compliance contractors and other FLA/COM users who verify Code compliance were asked if they would supply electronic copies of the input files for as many commercial buildings as they had available. Over 1,200 self-selected input files were received. To correct for potential self-selection bias, a sample of hard copy filings were also obtained using random selection methods.

Hard Copy FLA/COM compliance filings. Hard copy Florida Energy Efficiency Code compliance forms were obtained from the Department of Community Affairs (DCA) Tallahassee facility. A total of 500 forms were gathered: 150 from the North DCA climate, 150 from the Central DCA climate, and 200 from the South DCA climate. Documents collected consist of Code compliance forms for new buildings only (additions, retrofits, and residential buildings were excluded from the sample frame), generated using the DCA FLA/COM software version 1993 or 1997. In particular, Form 400's were collected that had been generated using the Method A whole building performance approach. Forms generated using 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 the goal was to collect the more complete FLA/COM information required to characterize the new construction market, efforts were focused on gathering the forms that included the detailed output.

FLA/COM compliance document findings. The compliance forms indicate the size and type of buildings constructed in each climate zone, as well as each building's FLA/COM-

derived "compliance score" (the energy usage as a percentage of the Energy Code "budget" of 100.) As shown in Figure 1, the Code compliance documents suggest that builders are already submitting buildings that substantially exceed Code requirements. In other studies (RLW Analytics 1999, Quantum Consulting 1995), 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.

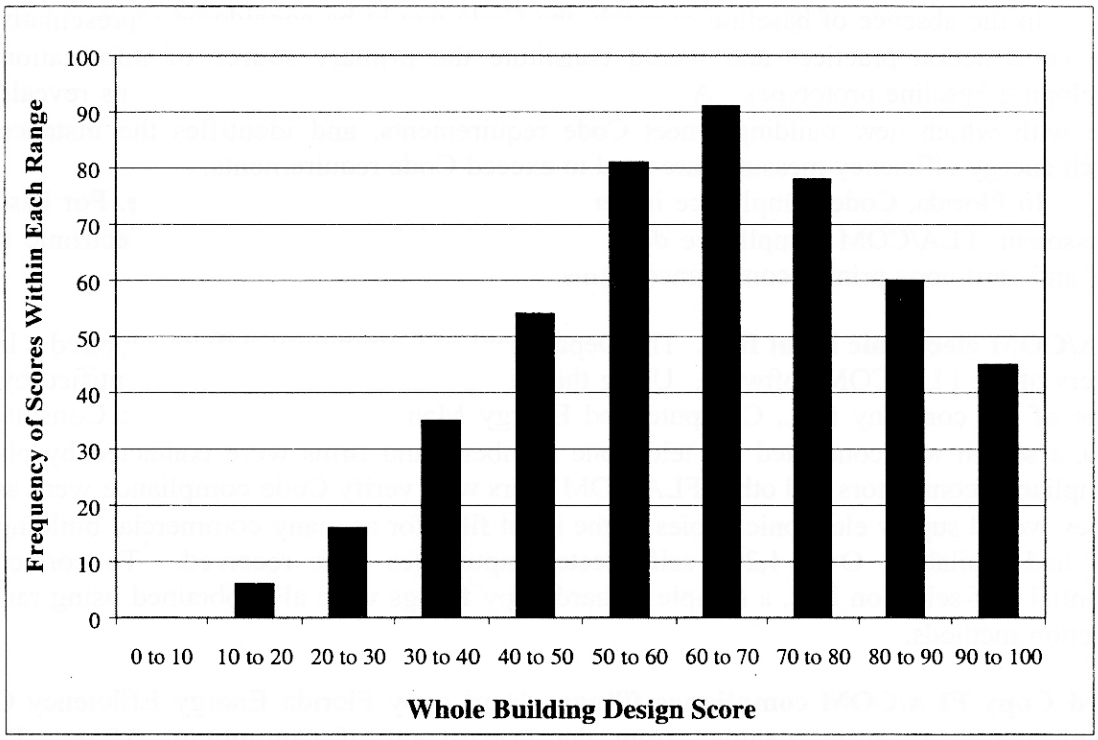

Figure 1. FLA/COM Whole Building (Method A) Compliance Scores

The bell shaped curve in Figure 1 implies that the commercial new construction market already supports building practices that exceed the Florida Energy Code requirements. In the absence of these findings, and of further research that unveils current building practices, a commercial new construction program based on the Code would very likely encourage large-scale free ridership.

Another way to interpret this result, however, is that the ASHRAE 90.1 compliant Florida Energy Code adopted in 1997 may not be functional or effective in shifting the current commercial market towards more efficient practices.

- New commercial buildings meet Code requirements even when installing small unitary cooling equipment with efficiency levels of just 10-11 SEER, i.e. equipment that barely exceeds the National Appliance Energy Conservation Act Standard.

- The installation of R-10 ceiling insulation and electric strip heating systems, while allowed in the mild FPL heating climate, are not exemplary technology choices from an energy efficiency standpoint.
- The allowed 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 State of Florida should consider improvements to the Code that will stimulate market movement towards more efficient building design. Market research (RLW Analytics 1999) has shown that periodic code review and revision is necessary to reflect progressive practices. Without code revision, the market might actually be held back from adopting energy efficiency measures by the view that code represents appropriate design practice.

Other Data Sources Used in Baseline Development

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

Issues and concerns regarding the use of FLA/COM data for baseline studies. Although a significant number of detailed records regarding current design practices in the commercial new construction market in FPL's territory were obtained, the FLA/COM data, by themselves, are insufficient in several areas of building design.

- While overall lighting power densities are specified by the Florida Energy Code, FLA/COM does not contain data on lighting levels or the specified technologies. It is not clear, for example, whether the current new design/construction practice is to specify and install T8 fluorescent lamps and electronic ballasts, or 34 W 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 required by FLA/COM as an input. Other examples of significant energy efficiency technologies not included in the files are data on HVAC economizers, programmable thermostats / EMS's, 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 FPL.

Solutions to the FLA/COM issues. We addressed the above shortcomings of the FLA/COM data by supplementing them with data from other sources, as follows.

- Surveys with architecture and engineering (A&E) firms were used to gather data regarding lighting, refrigeration, and cooking technologies used in current design. Specifically, A&E firms who specialize in supermarket design were contacted 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 and Industrial Sector Study was used to support information regarding the characteristics, energy usage, and load shapes of the business types of interest (Regional Economic Research Inc. and ADM Associates 1997).
- Commercial Buildings Energy Consumption Survey data from the DOE's Energy Information Administration were also obtained (CBECS, Energy Information Administration 1995), and served to fill gaps in the baseline characteristics extracted from FLA/COM and saturation data sources. The CBECS 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.

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, the baseline attributes found in the Code documents were verified based upon as-built specifications collected during on-site audit activities.

Field-Measured Baseline Verification and Adjustment

To verify the preliminary baseline established thus far, on-site audits were conducted in 100 new commercial sites. Where possible, the sites were selected from the larger sample of submitted energy code records, allowing for a direct comparison of characteristics/features between submitted Code compliance forms and as-built buildings. Additionally, detailed information was collected from the end uses that are not governed by the Code (especially indoor lighting and refrigeration). Some of the findings of the field-measured baseline verification are described below.

- There is no clear relationship between the submitted, energy code-based, ceiling/roof insulation level and that obtained during on-site audits. That is, the level of insulation that is specified in the compliance documents as part of the permit application process has little to do with the insulation level eventually installed in a building (Table 2).

Table 2. Comparison of Average Roof Insulation Levels for a Nested FLA/COM and On-site Audit Sample

Business Type	Average R-value (hr-ft^2-^{o}F/Btu)		Sample size
	FLA/COM Composite Roof System	Installed Roof Insulation	
Small Office	5	17	14
Restaurant	7	5	6
Small Retail	7	9	17
School	7	20	3

A related finding is that many of the audited buildings have no insulation in the ceiling or roof. In all likelihood this result is related to the requirements of the Code, which states that roof/ceiling compliance using Method A "… shall be in accordance with the procedures contained within… the FLA/COM computer program." The FLA/COM

code allows the designers to specify varying levels of roof/ceiling insulation, including "none." The ceiling assembly U-values specified in many of the compliance forms examined suggest that even buildings with zero ceiling insulation can comply with the Code.

- There is a strong and consistent relationship between window area as a function of conditioned building area in the submitted energy code records and the on-site audit-based findings. As far as glass type is concerned, however, the on-site audits suggest that there is both a greater fraction of glass that is tinted (33%) and a higher incidence of dual pane glass (13%) than submitted Code records indicate for the new construction building population (17% tinted, 8% dual pane).
- There is considerable agreement between submitted Code records and on-site audit findings regarding the air-conditioning (AC) capacity installed per conditioned building area (320 sqft/ton from FLA/COM vs. 310 sqft/ton from on-site audits). The efficiency level of AC packaged equipment reported in the code records (9.5 EER) also agrees with the efficiency level found by the on-site audits (9.6 EER).
- The submitted Code records clearly overstate the frequency with which heating systems are "absent" (10% reported in FLA/COM vs. 0% from on-site audits).
- Regarding the indoor lighting power density, there is reasonable agreement between submitted Code records and on-site audit findings. However, for some business segments, the audit records clearly indicate that the FLA/COM based allowed lighting power density overstates the actual installed lighting levels (Table 3).

Table 3. Comparison of Average Lighting Power Densities for a Nested FLA/COM and On-site Audit Sample

Business Type	Average Lighting Power Density (W/sqft)		Sample size
	FLA/COM	Installed	
Small Office	1.66	1.30	15
Restaurant	1.67	1.70	7
Small Retail	1.71	1.85	19
School	1.86	1.30	3
All	1.63	1.53	44

- Regarding indoor lighting technologies, the on-site audits indicate that a mix of efficient and inefficient fixtures is currently installed in new buildings. These findings largely agree with results from Trade Ally interviews and highlight the technologies and business segments where there are significant opportunities for program influenced transformation.

These findings may indicate that internal safety checks performed by FLA/COM during data entry are inadequate, leading to submitted records that inaccurately describe actual building design. Alternatively, given the not-so-stringent Code requirements, compliance contractors

might rely on default FLA/COM settings and only enter the actual design characteristics that will allow the developer to obtain building permits. Checking/validation of FLA/COM simulations could be a valuable feature of an FPL commercial new construction program. Code compliance verification through utility-financed commissioning assistance is another program design feature that will be considered.

Prototype Calibration

The baseline characterization phase of FPL's Commercial New Construction research project concluded with the adjustment of business-specific prototypes using the on-site audit information. As specified, prototypes were developed for 10 business types selected by FPL, and representing the most important new construction segments. The prototypes were calibrated using FPL's Commercial and Industrial Sector Survey data, as well as whole-premise metering data obtained from 27 of the 100 audited sites.

ECM Ranking

In phase two of this research project, the end use prototypes were used to estimate hourly energy use of new buildings in the FPL service territory. With baseline modeling completed, ECM energy use effects were simulated, yielding hourly demand impact profiles. Annual energy usage effects were estimated using summed differences between these profiles, and demand effects were estimated using selected hourly peak day results. These engineering impacts were then used in conjunction with measure saturation data to estimate each measure's technical potential.

In addition to the impact estimates, incremental installation and maintenance cost data were collected to support cost-effectiveness calculations. Estimates of payback were used, for example, to assess each ECM's cost-effectiveness from a customer perspective.

By rolling up the results from 10 business segments and 3 climate zones to the FPL system level, measures were ranked in terms of both impacts and cost-effectiveness. In this way, the most desirable program ECM choices were identified.

Next Steps in the FPL Program Design

In the third and fourth phases of this research effort, program elements will be designed that consist of the highest-ranking ECM measures. Interviews will be conducted with players in the construction market to assess the receptivity of alternative program designs. The end use models will be used to quantify the impact potential of various packages of measures. Impact and cost-effectiveness results will be used along with a review of existing new construction programs to recommend the best overall program design. Given the thorough research of baseline building practices conducted in the initial phases of this project, FPL can be confident that the program design will rely upon an accurate measurement of ECM impacts.

This research will culminate with recommendations for a program format that maximizes energy benefits in a cost-effective manner. FPL will then be in a position to implement an appropriate and viable Commercial New Construction Program, specifically designed for its territory.

Conclusions

To properly design and test the cost-effectiveness of a commercial new construction program, the use of accurate energy and demand savings estimates, obtained using accurate baseline models, is essential. The data collection and analysis methods described in this paper ensure that these objectives are achieved in FPL's forthcoming Commercial New Construction Program. Similar research projects, conducted in other utilities' service territories, would lead to informed decisions in the design of new programs.

The State of Florida should consider improvements to the Florida Energy Code that will stimulate market movement towards more efficient building design.

References

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