Streamlining the Small Commercial New Construction Market: a Prescriptive Approach to Comprehensive Savings with Core Performance

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ABSTRACT

One of the greatest challenges for energy efficiency programs is to achieve comprehensive energy savings in the small commercial new construction market. This market represents a significant "lost opportunity," accounting for substantial portions of new floorspace and new construction projects. But, for these small projects, efficiency programs typically offer prescriptive incentives on a limited range of technologies, at most achieving effective lighting design but overlooking controls or system interactions. One reason is that energy modeling is cost-prohibitive for smaller projects. Another is that designers lack the time or incentive to determine and hit "high performance" targets on each project and satisfy administrative requirements for unpredictable incentive offers. Third, building owners and/or occupants lack concrete information up front to support a commitment to energy efficiency.

Fortunately, New Buildings Institute's new Core Performance program provides an opportunity for Efficiency Vermont to establish a low-cost, high-volume approach to comprehensive savings in this market. Core Performance sets national prescriptive design targets which achieve energy savings of 20 percent or more over Vermont's new commercial energy code. With New Buildings Institute, Efficiency Vermont has developed a "savings matrix" across a range of building types, sizes, and operating conditions, providing both normalized energy savings and cost estimates. By pairing standard incentives with these savings and cost estimates, Efficiency Vermont creates a more predictable process for design professionals, end use customers, and staff. This paper discusses the challenges of the small commercial construction market, provides a brief overview of the development of Core Performance, summarizes the results of the analysis, and identifies steps that Efficiency Vermont has already taken in implementing this approach.

Introduction

Nationally, the small commercial construction market accounts for a significant amount of floorspace and energy consumption, but relatively small energy savings opportunity per project. For this purpose of this paper, "small commercial" buildings are between 10,000 ft2 (about 930 m2) and 70,000 ft2 (about 6,510 m2) in area. While Energy Information Administration data do not exactly match this building size, this section reviews buildings between 10,000 ft2 and 50,000 ft2 in size.

Table 1. Number of Buildings, Floorspace, and Energy Use by Size (National)

	Less than 10,000 Square Feet	10,000 to 25,000 Square Feet	25,001 to 50,000 Square Feet	50,001 to 100,000 Square Feet	Over 100,000 Square Feet
Floorspace (million ft2)	12,543	11,371	8,386	9,031	21,978
Sum of Major Fuel (trillion Btu)	1,188	776	672	759	2,227
Electricity Use (billion kWh)	189	119	103	118	360
Number of buildings (thousand)	3,440	738	241	129	97
Electricity per Building (MWh)	55	161	427	915	3,711

Table 1 presents national information on the number of buildings, total area, and energy use (total and electric). Small commercial construction accounts for 21 percent of new construction projects, 31 percent of floorspace, and 25 percent of electricity use. The same data shows that, on a per-project basis, the annual total energy consumption for a small building is about 1,480 MMBtu, while for a larger building (i.e., greater than 100,000 ft2) is almost 23,000 MMBtu. The implication in program design generally is that small commercial buildings are far greater in number with significantly less energy consumption in which to find efficiency savings.

For electricity efficiency programs specifically, the lower energy consumption per building and the volume of small commercial projects has led to different strategies to address efficiency opportunities in the small and large submarkets. The EIA data indicate that the average electricity consumption for a small commercial building is about 227 megawatt-hours per year (MWh) for a small building, and 3,711 MWh/yr for a large building. If, for comparison's sake, one assumes that an electricity efficiency program will spend $250 per MWh/yr of savings to attain a target of 20 percent savings, the available budget is only $11,340 ($250 per MWh multiplied by 45 MWh) for the smaller building, versus over $185,000 for the larger one. Based upon the available per-building project, a program manager would decide to use a low-cost, high volume strategy (such as prescriptive incentives), possibly combined with outreach, for smaller buildings. While keeping pace with the number of small construction projects, this approach often leaves substantial energy savings "on the table." For larger buildings, the program administrator could afford to use business development and technical assistance services within the available per-project budget, and can frequently attain savings levels higher than 20 percent.

What is true of efficiency programs is often also true of the community that designs, builds, and pays for those buildings. Smaller overall design and construction budgets on smaller buildings provide less room to accommodate innovative design approaches or construction methods. The availability of time for design professionals – architects and engineers – to research and evaluate alternatives can be more limited by shorter design and construction timeframes on smaller projects. Across all projects, design professionals have provided feedback to efficiency programs asking for a more transparent, less time-intensive means for engaging on projects, where both process and potential incentives are more clearly understood at the onset of project efforts (Boucher 2007).

The ability of Efficiency Vermont to claim savings in the new construction market has also become more challenging since the adoption of Vermont's first commercial energy code. The code, the 2005 Vermont Guidelines for Energy Efficient Commercial Construction (Vermont Code), is based upon both ASHRAE 90.1-2004 and the 2004 International Energy

Conservation Code, but adds more stringent requirements for building envelope. By tightening lighting power density and building envelope U-value requirements over the 2001 version, the Vermont Code lowered the starting energy use index for commercial new construction, so that the same percentage reductions in energy use now provide lower absolute amounts of energy savings. While the design community is now adjusting to the Vermont Code, the Vermont Department of Public Service requires Efficiency Vermont to treat the Vermont Code as baseline.

In this context of low energy use in small buildings and higher costs per MWh of savings, Efficiency Vermont sought a streamlined, predictable process to promote high-performance design to design professionals and customers for small commercial new construction. As a sponsor of New Buildings Institute's Advanced Buildings initiatives, Efficiency Vermont viewed the new Core Performance Guide as a significant opportunity.

New Buildings Core Performance – Development and Structure

New Buildings Institute ("NBIs") released its Core Performance Guide ("CP Guide") in 2007 as a "'how-to' document for building professionals that provides a clear, easy-to-follow and easy-to-implement path to improved energy performance in buildings" (NBI 2007). With the opportunities and challenges of smaller buildings in mind, NBI developed the CP Guide to apply to commercial buildings between 10,000 and 70,000 ft2 in size. NBI also targeted office, education, public assembly, and retail buildings because those building sub-types account for just over half of the floorspace in the building size category. The CP Guide relies upon "state-of-the-shelf" technologies and practices that are broadly available in the building industry and that have been proven to be cost-effective. This section of the paper summarizes the development process and provides an overview of the CP Guide's structure.

Development Process Overview

New Buildings Institute (NBI) developed the Core Performance Guide by conducting a series of simulation models for three building types (office, retail, and school), 12 different mechanical systems (five for office, four for school, and three for retail), and 16 different cities to represent the eight ASHRAE climate zones. NBI began with a list of approximately 20 different efficiency measures, which NBI's modelers (the same developers of the eQuest software package, using DOE-2 as a calculation engine) evaluated individually for each building type, mechanical system (as appropriate), and weather file. NBI used ASHRAE 90.1-2004 as a baseline.

The goal of the modeling protocol was to "stack" energy efficiency measures in order of the amount of energy savings provided. Thus, the modeling protocol identified the efficiency measure that provided the greatest energy savings, added that measure to the package, and then re-ran the full protocol. The protocol then again sorted the results by energy savings, added the greatest energy-savings measure to the package, and continued in that manner. Comparing results across building, mechanical system, and climate, NBI found that a "core" set of efficiency measures provided consistent energy savings across all climate zones. With feedback from an industry review group, NBI identified a subset of those measures that are both cost-effective and readily available in the market, labeling those measures as their "Core Performance

Requirements." NBI labeled measures that provide climate-specific savings, rely on "state-of-the-art" technologies, or have widely varying costs, as "Enhanced Performance Strategies."

Core Performance Guide Structure

NBI organized the CP Guide according to implementation strategies, the results of the modeling protocol, and an alternative energy simulation modeling track:

- Section 1: Design Process Strategies lays out a series of approaches to ensure that the customer and design team set common goals, that the design process will take advantage of system efficiency improvements, and that the completed building will perform as intended.
- Section 2: Core Performance Requirements establishes the measures and associated efficiency targets for the core set of measures.
- Section 3: Enhanced Performance Strategies establishes the measures and associated efficiency targets for the enhanced measures.
- Section 4: Energy Modeling.

The CP Guide has already gained national recognition within the industry – the U.S. Green Building Council utilizes the CP Guide as an alternative path to obtaining energy points in its Leadership in Energy and Environmental DesignTM (LEEDTM) rating system, without completing energy modeling.

As a sponsor of Core Performance, Efficiency Vermont considered the modeling work conducted by NBI to be an opportunity to develop a prescriptive approach to comprehensive efficiency savings in commercial new construction. *Core Performance* also confers some advantages over other design guides (e.g., the *Advanced Energy Design Guide (AEDG) for Small Office Buildings*) because *Core Performance* uses ASHRAE 90.1-2004 as a baseline, applies to a wider range of building sizes, and is deliberately configured for a "low-cost, high-volume" approach. While AEDG arguably promotes deeper savings, *Core Performance* provides a more straightforward approach to achieving both incremental and more substantial design improvements.

Vermont's Prescriptive Approach

In developing a prescriptive approach, Efficiency Vermont needed to answer three key questions:

1. Does the CP Guide and protocol apply to the Vermont Code and typical Vermont construction practices? If not, how should it be revised?
2. Does the CP Guide and protocol yield predictable, cost-effective energy savings, by building type and/or building size?
3. Can a prescriptive approach be developed for Vermont from the CP Guide?

Modeling Protocol

Efficiency Vermont then worked with NBI to undertake a Vermont-specific modeling protocol that would ensure the cost-effectiveness of each individual measure, and then determine the impact of a package of only cost-effective measures. The protocol evaluated three different building types: office, school, and retail. The first models – developed to check the cost-effectiveness of each measure – used a 30,000-ft2 office building, a 50,000-ft2 school, and a 10,000-ft2 retail building. Efficiency Vermont chose metal framing for the building envelope (walls and roof) and metal-frame windows for glazing. Efficiency Vermont also chose to evaluate the following mechanical systems:

Four office mechanical systems

- Package VAV with water coils ("PVAV-HW")
- Single zone DX with hot water baseboard ("SZRH")
- Single zone DX with furnace ("PSZ-Furn")
- Water loop heat pump ("WLHP")

One school mechanical system

- Unit ventilators and package rooftop units (e.g., for gymnasiums) ("UVT-HW")

One retail mechanical system

- Single zone DX with furnace ("PSZ Gas")

In conducting the energy simulation models, Efficiency Vermont and NBI used the same building envelope and mechanical system; thus there were six different baselines evaluated. The difference in each scenario was the efficiency performance specified by Vermont Code and Core Performance. Table 2 summarizes the criteria that NBI modeled and the performance target differences for each.

Table 2. Energy Modeling Performances for Baseline (Vermont Code) and Vermont Core Performance (Office Building Example)

Criteria		Vermont Code	Core Performance
2.5	Envelope		
	Floor/Slab	R-10 for 48"	R-10 for 48"
	Wall	R-13 + R-7.5 ci	R-19 + R-10 ci
	Roof	R-24 ci	R-30 ci
2.6	Fenestration	U 0.5, SHGC 0.4	U 0.45, SHGC 0.3
2.7	Lighting Controls	Manual control, bi-level, auto shutoff	Bi-level, separate daylight switching, controls
2.8	Lighting Power Density[1]	1.0 W/ft2	0.9 W/ft2
2.9	Mechanical System Eff.		
	DX Cooling	10.3 EER	11.5 EER/11.9 IPLV
	Boiler	80% Et	86%Et
	Water Loop Heat Pump	12 EER, 4.2 COP	14 EER, 4.6 COP

Criteria		Vermont Code	Core Performance
	Chilled Water System	4.45 COP, 4.5 IPLV	4.5 COP, 5.86 COP
	Package Rooftop	80% Et	80% Et
2.11	Demand-Controlled Vent.	Meet ASHRAE 62	DCV in occupied spaces in building
2.12	Hot Water System Efficiency	Pipe insulation, heat traps	Instantaneous hot water system, high-eff., or sealed combustion. R-14 on tanks
2.13	Economizer Performance	100% outside air, drybulb	Dual-enthalpy, factory-installed, fully-modulating, damper-drive, etc.

[1] For retail buildings, the Vermont Code requires 1.5 W/ft2, while the Vermont Core Performance requires 1.3 W/ft2; for school buildings, the Vermont Code requires 1.2 W/ft2, while Vermont Core Performance requires 1.08 W/ft2.

One important finding in the modeling was that demand-controlled ventilation as a measure resulted in an increase in energy consumption – both electric and fossil fuel – for a variable air volume ("VAV") system. The energy model assumes that if one zone calls for additional outdoor air, the central air handling unit provides additional air to all zones that the unit supplies, increasing heating and cooling costs in all other zones.

Efficiency Vermont also conducted research to derive general incremental cost estimates for each of the efficiency components for the energy modeling. Not all efficiency measures for which incremental costs could be identified were modeled for determining energy savings: specifically, air infiltration was not included in the modeling (because the Vermont Code does not specify an infiltration target in terms of air changes per hour); and dedicated mechanical cooling systems (which is a highly site-specific measure, and could not be characterized for a generalized case). Efficiency Vermont determined total costs by multiplying the researched incremental costs by the appropriate parameter from the computer model.

The initial cost-effectiveness findings indicated that the wall and roof insulation measure did not pass the cost-effectiveness test in the office and retail building prototypes, and only passed in school buildings using propane as their heating source.[1] Demand-controlled ventilation did pass as a measure in the non-VAV office simulations, as well as in schools and retail (where it provides significant savings). NBI adjusted the Core Performance package to take these results into account.

To conduct a sensitivity analysis, NBI developed office model prototypes over a range of sizes, from 20,000 ft2 to 70,000 ft2. Efficiency Vermont reviewed the results of these models to assess the sensitivity of results to building size. Based upon their experience, NBI suggested that the office sensitivity model results be viewed as indicative of the results that would be generated for the school and retail prototypes.

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[1] Vermont uses the societal test to determine cost-effectiveness, and propane has higher avoided costs per MMBtu than fuel oil, natural gas, or wood heat.

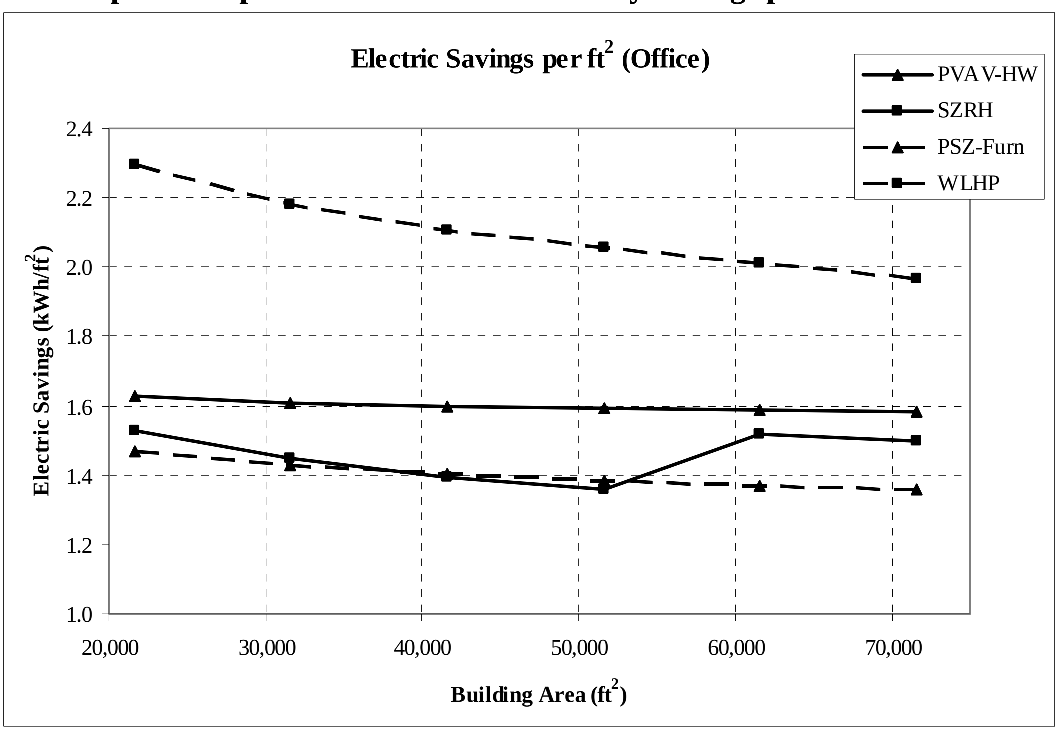
Modeling Results

The modeling indicated a relatively consistent electricity savings per square foot of building area. Table 3 and Figure 1 summarize the results for the four office mechanical systems, and the school and retail models (only one model run apiece). The water loop heat pump model run for office buildings provided the greatest savings at about 2.1 kWh/yr per ft2. The chilled water office system saves about 1.6 kWh/yr per ft2, and the remaining office systems save slightly more than 1.4 kWh/yr per ft2.[2] School energy savings are lower (fewer operating hours per year and less space cooling) while retail savings are higher (significant benefits from demand-controlled ventilation). Retail savings represent 20% of baseline electric consumption. Percent savings estimates range from 10% to 14% for all other building/mechanical system types.

Table 3. Electric Savings per Square Foot (kWh/yr per ft2)

		Size (ft2)					
Building Type	**Mech System**	**21,600**	**31,599**	**41,592**	**51,592**	**61,590**	**71,608**
Office	PVAV-HW	1.63	1.61	1.60	1.59	1.59	1.58
	SZRH	1.53	1.45	1.40	1.36	1.52	1.50
	PSZ-Furn	1.47	1.43	1.40	1.38	1.37	1.36
	WLHP	2.30	2.18	2.11	2.05	2.01	1.97
School	UVT-HW	0.57					
Retail	PSZ Gas	2.12					

Figure 1. Graphical Depiction of Modeled Electricity Savings per ft2 for Office Buildings



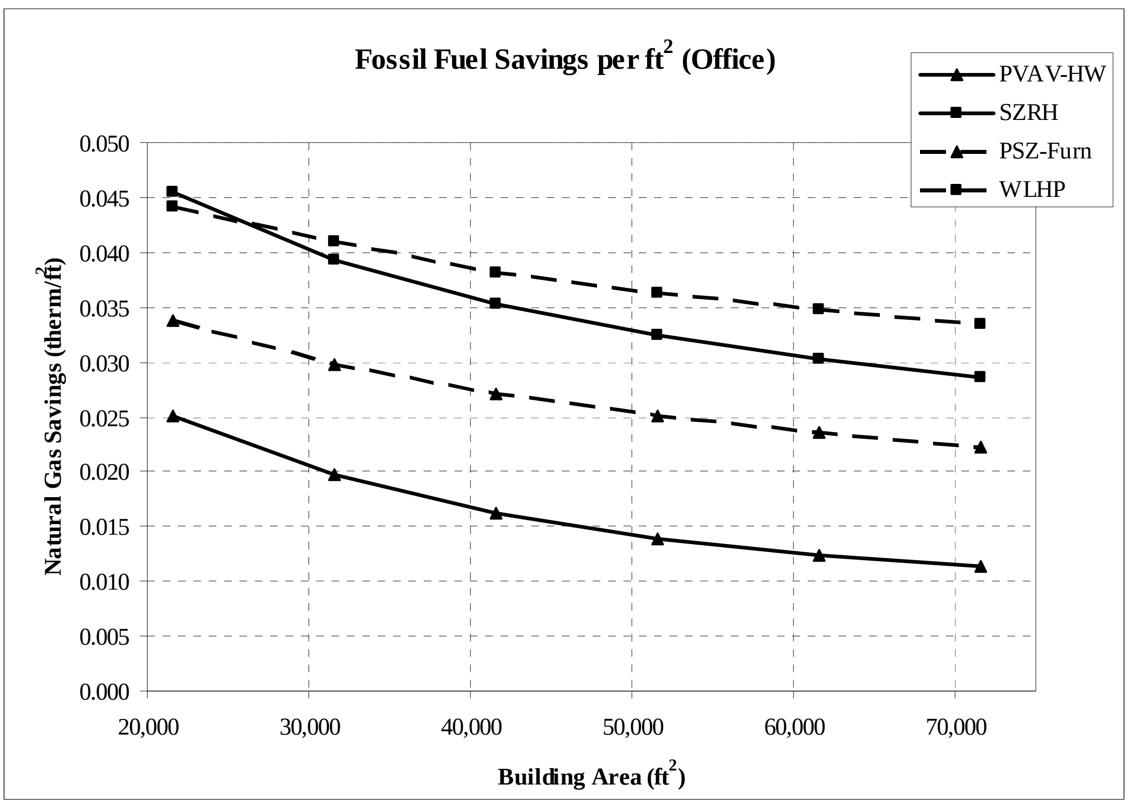
[2] The jump in savings per ft2 for the Single Zone DX with hot water baseboard results from a size change in equipment, with changes in baseline and CP Guide efficiency requirements.

Table 4 and Figure 2 summarize the modeled fossil fuel savings. In this case, savings were a stronger function of building area. Because the same thermal efficiencies were assumed for the different fuel types prevalent in Vermont – natural gas, propane, and fuel oil – these results can be applied to all buildings in Vermont, regardless of location. The high level of energy savings in the retail model stemmed largely from demand-controlled ventilation, relative to a baseline condition assuming adequate mechanical ventilation based upon assumed time clock schedules.[3] Estimates of percent savings over baseline fossil fuel consumption range from 9% to 52% with the Office-WLHP model demonstrating the highest savings levels.

Table 4. Fossil Fuel Savings per Square Foot (therm/yr per ft2)

		Size (ft2)					
Building Type	**Mech System**	**21,600**	**31,599**	**41,592**	**51,592**	**61,590**	**71,608**
Office	PVAV-HW	0.025	0.020	0.016	0.014	0.012	0.011
	SZRH	0.045	0.039	0.035	0.032	0.030	0.029
	PSZ-Furn	0.034	0.030	0.027	0.025	0.024	0.022
	WLHP	0.044	0.041	0.038	0.036	0.035	0.033
School	UVT-HW	0.091					
Retail	PSZ Gas	0.243					

Figure 2. Graphical Depiction of Modeled Fossil Fuel Savings per ft2 for Office Buildings



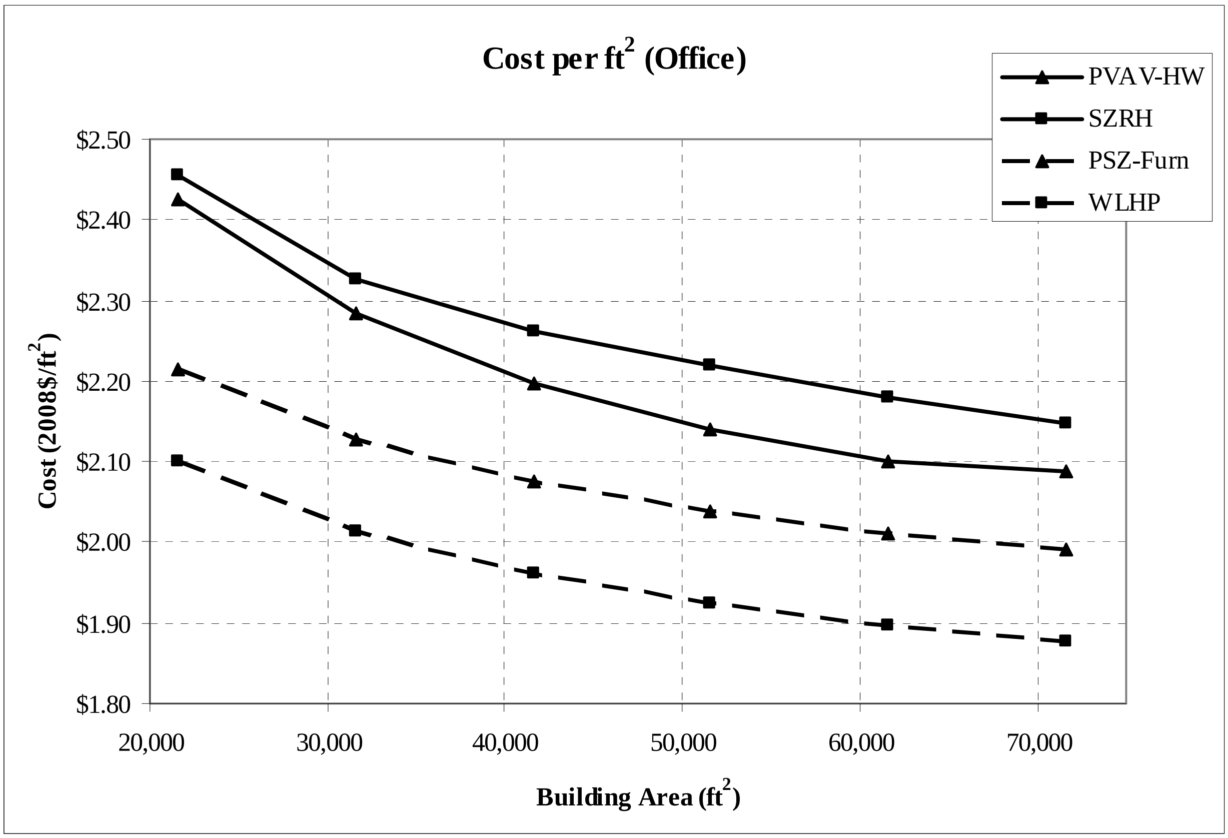
[3] It is possible that fossil fuel savings for the retail building type would be lower if the building utilized volatile organic compound (VOC) sensors to determine the need for outdoor air (due to retail product offgassing), and if the VOC controls resulted in a lower outdoor air intake baseline. However, the Vermont Code does not call for these controls.

Finally, Table 5 and Figure 3 present the incremental costs associated with the office, school, and retail models. Incremental costs are higher for the single zone with baseboard system, and lowest for the water loop heat pump system.

Table 5. Cost per Square Foot ($/ft2)

		Size (ft2)					
Building Type	**Mech System**	**21,600**	**31,599**	**41,592**	**51,592**	**61,590**	**71,608**
Office	PVAV-HW	$ 2.43	$ 2.28	$ 2.20	$ 2.14	$ 2.10	$ 2.09
	SZRH	$ 2.46	$ 2.33	$ 2.26	$ 2.22	$ 2.18	$ 2.15
	PSZ-Furn	$ 2.21	$ 2.13	$ 2.08	$ 2.04	$ 2.01	$ 1.99
	WLHP	$ 2.10	$ 2.01	$ 1.96	$ 1.92	$ 1.90	$ 1.88
School	UVT-HW	$ 2.06					
Retail	PSZ Gas	$ 2.23					

Figure 3. Graphical Depiction of Incremental Cost per ft2 for Office Buildings



Proposed Implementation Strategy

Efficiency Vermont concluded that the data sufficiently support a prescriptive approach to claiming whole-building savings. The initial strategy is to use a single energy savings number per square foot for both electric energy and fossil fuel savings, designed to represent a conservative (i.e., low) estimate as building size changes. However, the modeling protocol only works for those buildings that match the modeled prototypes (i.e., office, retail, and school buildings with the specified mechanical systems) and that exactly hit the *Core Performance* targets. As a result, Efficiency Vermont is also developing a simplified tool to evaluate buildings that follow the *Core Performance* requirements but do not fit the modeling protocol.

Proposed Incentive Package

Efficiency Vermont plans to offer the following financial incentives for office, school, and retail projects up to 70,000 ft2 that complete the Design Process Strategies (Section 1) and the Core Performance Requirements (Section 2) of the Core Performance Guide – Vermont Edition:

- Section 1: $0.10/ft2 plus $2,500 toward the cost and installation of a meter to comply with credit 1.7 (see "Ongoing Building Performance Evaluation," below); and
- Section 2: $0.50 per ft2 to attain the required efficiency targets (see Table 1).

Efficiency Vermont also proposes a 5% penalty on claimed savings for projects that do not fully complete Section 1. This is higher than a savings-weighted average of the "operational testing" factors for measures that currently impose such penalties in Efficiency Vermont's prescriptive savings algorithms (i.e., economizers, demand-controlled ventilation). This is because most electrical energy savings for the CP Guide derive from measures that do not currently have "operational testing" or commissioning factors (e.g., lighting power density, cooling efficiency, lighting controls).

Proposed Implementation Process

To implement this Core Performance approach, Efficiency Vermont will work with design professionals to meet – and hopefully exceed – the Core package.[4] Efficiency Vermont staff will share and review the requirements of the Core Performance Guide with members of the design team. The design team will be encouraged to present its strategies on meeting the intent of the Design Process Strategies, which will be reviewed on a case-by-case basis by Efficiency Vermont staff. Efficiency Vermont staff will review proposed designs for consistency with the Core Performance Guide, answering any questions about "gray areas" in interpretations. Efficiency Vermont staff will also verify installation according to the Core Performance Guide at the completion of each project. Efficiency Vermont plans to claim prescriptive savings for completed projects that meet the Core package, and to claim custom savings for those measures that go beyond.

As mentioned earlier in this section, Efficiency Vermont also needs to determine how to apply the CP Guide to projects that do not exactly match the modeled building and mechanical system types. This may occur because the design team is integrating Enhanced Performance Strategies, is considering a less standard mechanical system (e.g., ground-source heat pumps), or is attaining efficiency levels that go somewhat beyond the Core Performance Requirements (e.g., better HVAC equipment efficiencies). To do this, Efficiency Vermont is working with NBI to develop a simplified eQuest interface that will allow the entry of design information, automatically look up related Vermont Code requirements, and broaden the range of measures addressed by the energy efficiency measure wizard.

[4] Preliminary modeling results indicate that the daylighting and enhanced lighting power density measures could nearly double the electric savings provided by meeting the Core package.

Ongoing Building Performance Evaluation

Credit 1.7 of the Design Process Strategies ("Performance Data Review") requires ongoing metering of building performance. Specifically, the credit requires the collection of hourly metered electric and other fuel (e.g., natural gas, oil, propane) use data via an automatic data collection system with data logging and communication capability. (NBI is collecting this information and will generate a quarterly report for the building owner on building performance). Efficiency Vermont will provide a financial incentive toward the purchase of this system, as well as a sample specification to include in construction bid documents. Efficiency Vermont plans on a more thorough review of performance data to refine the savings algorithms based upon actual building performance.

Vermont Implementation – Looking Ahead

Efficiency Vermont has already conducted a day-long training in conjunction with New Buildings Institute at Efficiency Vermont's Better Buildings by Design conference. Efficiency Vermont plans to participate in a number of "lunch & learn" sessions at architecture and other firms, and will schedule follow-on trainings later in 2008. At the end of 2008, Efficiency Vermont will assess the experiences of its own staff, design professionals, and customers with the Core Performance process, and will modify that process as needed.

Efficiency Vermont has also proposed a measurement and verification ("M&V") plan for participation in the New England Independent System Operator's ("ISO-NE's") Forward Capacity Market ("FCM"). This M&V plan will require compliance with the Performance Data Review credit, site visits of all completed Core Performance projects, comparison of performance with modeled results for a stratified sample, and adjustment of the savings algorithms.

Conclusions

Efficiency Vermont found New Buildings Institute's new Core Performance program to provide an opportunity to establish a prescriptive approach to comprehensive savings in this market. Because Core Performance is a national approach, Efficiency Vermont needed to work with New Buildings Institute to evaluate the impact of local conditions, including energy codes and construction practices, on the modeled results. After removing individual measures that failed Vermont's statewide cost-effectiveness screening, Efficiency Vermont created a "Vermont edition" of Core Performance and proposed a "savings matrix" across a range of building types, sizes, and operating conditions, providing both normalized energy savings and cost estimates. By pairing standard incentives with these savings and cost estimates, Efficiency Vermont believes that it will create an administratively-streamlined and more predictable process for design professionals, end use customers, and staff, and has designed an implementation strategy to make the most of this new approach.

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