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INVESTING IN "GREEN" BUILDING ALTERNATIVES: U.S. CONSUMER WILLINGNESS-TO-PAY

By Kevin R. Grosskopf[1]

ABSTRACT: As natural resources worldwide become more distant and dilute and as efforts to internalize the once externalized costs of resource extraction and pollution intensify, new emphasis is being placed on the lifecycle performance of a building, not simply the turnkey cost of construction. In response, contractors, construction managers and design-builders are fast looking for ways to package high efficiency bid alternates that offer consumers operational savings and higher- resale value while creating a market niche for themselves.

The following research examines the extent to which capital construction costs and life-cycle ROI affect consumer willingness to pay for "green" building alternatives, or those alternatives that provide direct payback to consumers in terms of reduced energy and other operational costs while promoting sustainable use of natural resources when compared to conventional practices. Specifically, the performance and subsequent return on investment of more than 100 high efficiency bid alternates simulated in the three major climatic regions of Florida were matched to a consumer willingness-to-pay survey of more than 400 new home-buyers in an effort establish a method for matching green building alternatives to a wide range of consumer groups most likely to invest in them.

KEYWORDS: Green Building; Life Cycle Performance; Return-on-Investment; Sustainable Economics; Willingness-To-Pay.

INTRODUCTION

Builders can readily create a competitive point of difference by providing marketable "green" building alternatives that in turn, provide the consumer an attractive return-on-investment. As survey research shows, total monthly outlays for new home mortgage payments and utilities are a significant factor in determining which new home to buy. Some builders have been quick to capitalize on high-efficiency green building materials and equipment that exceed minimum code requirements. The reason? Homebuyers are willing in many cases to spend more for efficiency upgrades if it can be demonstrated that the monthly utility savings will be equal to or greater than the increase in monthly mortgage payments. Since the builder's fee is often a percentage of construction costs, more money spent on higher performance equipment and quality materials means more profit with little or no added investment of time and resources. The consumer benefits from lower net monthly expenses and higher resale value. At a minimum, money that would otherwise go to the utility is now applied to the principal portion of each mortgage payment, building added equity.

However, a key factor inhibiting greater use of green building alternates is the builder's inability to assess and communicate their investment value, and, the investment preferences of the builder's market(s).

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Subsequently, the following study examines the extent to which initial costs and life-cycle return on investment affect consumer willingness to pay for "green" building alternatives, or those alternatives that provide savings to consumers in terms of reduced energy and other operational costs while promoting sustainable use of natural resources when compared to conventional practices. Specifically, the performance and subsequent return on investment for several high efficiency bid alternates simulated in the three major climatic regions of north, central and south Florida were matched to a consumer survey of more than 400 new home-buyers in each of these regions to enable builders to select the most competitive bid alternates based on savings potential and the composition of the builder's target market.

INVESTING IN GREEN BUILDING ALTERNATIVES: INVESTMENTS AND SAVINGS POTENTIAL

Two case-study housing units were selected to model the performance and subsequent "payback" of several green building alternatives, or those bid alternates surpassing minimum U.S. Model Energy Code (MEC) performance standards. These housing units were selected for their representativeness of typical single-family detached housing. The case-study units were considered representative of nearly 65% of residential structures in Florida; some 3.1 million units and 4.7 billion ft^2 total living space. Since the State of Florida has primarily three major climatic regions that could significantly affect the performance and corresponding cost savings of bid alternates, performance simulations were conducted in each of these areas. Specifically, Jacksonville, Orlando and Miami were selected to represent northern, central and southern zones since these areas not only provide the greatest climatic variance in the state, they also represent more than 44% of Florida's 14.5 million people and 50% of the state's total owner-occupant population living in single-family detached housing. High-performance green building alternatives, or those commercially available building materials and systems that exceeded the MEC, were assembled and "installed" individually into both case study housing units. The reductions in energy consumption observed for each case study unit, modeled in each of the three climatic regions were compared to the baseline scenario of minimally compliant MEC building components. The resulting annual energy savings attributed to each alternative was then divided by the unit quantities specific to each case study housing unit (e.g. area of glass), and the average heating and cooling degree-hours for each region.

For example, 6.5mm (¼") clear monolithic (single pane) glazing with metal frame represents the minimally compliant MEC baseline for both case study housing units. As a bid alternate, low-emissivity (LoE) glazing modeled in place of monolithic glazing was found to reduce the cooling load consumption of a 10.5kW (3-ton), 2.9 COP (10 SEER) air-source heat pump between 13.0kW-14.5kW (44.5-49.5MBtu) per $9.3m^2$ ($100ft^2$) of glass near equally distributed about E, W, N and S orientations, per thousand cooling degree hours (kCDH). A cooling degree-hour was defined as each 60-minute period that the outside temperature exceeded 23^oC (74^oF) by one degree. When normalized for the differences in glass area for each housing unit and differences in annual degree hours for north, central and south regions, the variance in energy savings observed for single-pane LoE windows was less than 8%. As a result, it was assumed that a single-pane LoE bid alternate may save an average of 49.5MBtu of HVAC consumption per $9.3m^2$ of glazing, per 1,000 cooling-degree hours per year, when used in place of the minimally compliant 6.5mm clear monolithic glass (see Figure 1).

Once the average energy reduction for each bid alternate was determined, the corresponding annual cost savings was calculated using a $US 0.085 per kWh cost for electricity and $US 0.85 per 30kW (Therm or 100,000Btu) cost for natural gas, both U.S. average energy costs obtained at the time of this study. Using this data, a newly constructed MEC compliant home in Orlando with a 2.9 COP, 10.5kW air conditioning system could pay an additional $US 300.00 for a 3.5 COP upgrade saving $US 128.76 per year in energy costs. In this scenario, the $US 128.76 per year in energy savings will payback the $US 300.00 added investment in roughly 2.33 years. Based on an average condenser unit life of approximately 15 years, the

3.5 COP bid alternate may save the consumer a total of $US 1,931.40 during its useful life. The total savings divided by the added upgrade cost of $US 300.00 results in a savings to investment ratio (SIR) of approximately 6.4, meaning the life-cycle savings of the 3.5 COP option is slightly less than six and one-half times the initial investment. Of course, this simple-payback method neglects the time-value of money which may increase the value of savings or discount them depending on the rate which energy costs increase or decrease with respect to inflation, the consumer's cost of capital, risk, opportunity costs and any other factor the consumer may include in deciding what discount rate represents their minimal attractive rate of return. However, this initial step is used only to prioritize the order in which multiple green building alternatives are inserted into the performance models for the reasons further explained below.

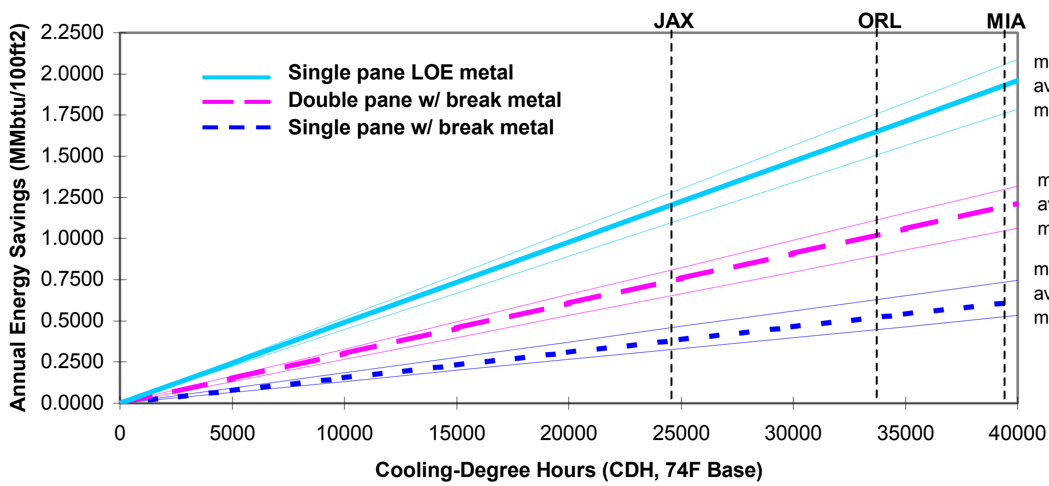

Figure 1: *Sample Energy Efficient Window Alternatives. Range and average energy reduction when modeled in place of MEC minimally compliant single pane, aluminum frame baseline (JAX = Jacksonville, ORL = Orlando, MIA = Miami).*

Selecting Multiple High-Performance Bid Alternates

Since energy alternatives in particular have a declining utility function whereby the benefits of each added alternative decline as the number of alternatives increases, the cumulative performance and cost savings of alternatives modeled independently of one another as discussed above could not be used in situations where multiple alternatives are implemented. In other words, the energy reductions and payback of each bid alternate modeled individually cannot simply be added together for a total energy savings and payback. Consequently, if the performance of more than one alternative is attractive and the initial cost affordable, multiple alternatives would have to be modeled together to determine the overall energy reductions as a system. For example, a double-pane LoE window with vinyl frame may reduce the energy consumption of a minimally compliant 2.9 COP HVAC system 2,285kWh per year, or roughly $US 2,902.68 over a period of 15 years. However, if the HVAC is upgraded to a 3.5 COP system, the savings attributable to the double-pane LoE windows is reduced to 1,904kWh per year, or $US 2,418.90. Of course, the overall energy savings continues to improve as each high performance bid alternate is added, but at a rate less than simply adding their individually modeled performance savings together. However, since the cost to implement each alternative *is* additive, the rate of return for multiple bid alternates declines rapidly as each new alternative is added.

Assembling "Packages" of Attractive Bid Alternates

For the reasons stated above, SIR was used to select the best performing bid alternate from a competing "family" of alternatives. For example, the 3.5 COP HVAC unit having a SIR of 6.44 was selected as the HVAC system alternate of choice since no other system, including those considerably more efficient, could better its savings-to-cost performance (Table 1). Next, the best performing bid alternates from each family of alternatives were ranked according to their respective SIR. After having been similated together, starting from the highest SIR bid alternate and *adding* the second highest, the third and so on, "packages" of multiple alternates were assembled by their cumulative payback and savings-to-investment ratio, the logic being that there must be a "cut-off point" where the added investment cost for more and more bid alternates would no longer be justified by the declining marginal returns of each added alternate. This cut-off point would be determined by the minimal attractive rate of return (MARR) of the consumer, and as determined by survey data to follow, this cut-off point would allow a shift in which groups or packages of alternatives would be attractive to which demographic groups of new homebuyers (Table 2). Depending on the initial investment cost and cost-savings performance of the bid alternate, and, the demographics of consumers, the builder would know which bid alternates would be most competitive to a given target market.

INVESTING IN GREEN BUILDING ALTERNATIVES: WHAT CONSUMERS HAVE TO SAY

Having established a methodology to screen hundreds of competing high-performance bid alternates and assemble packages consisting of only a few with the best rate of return, a survey was used to identify which of these the consumer is willing to pay for; a valuable tool to allow the builder or developer to know which bid alternates would be most competitive to a given target market.

Although not suprising, "cost" is the most important variable in the new-home buying decision making process of the consumer, carrying 42% of the overall decision weight compared to 34%, 17% and 7% for appearance, security and location respectively (Figure 2). Yet the data suggests that the willingness-to-pay decisions of certain demographic groups are affected by costs in different ways. Although costs remain the leading criteria for selecting high-performance alternatives, the extent that decisions are influenced by costs vary by demographic, mostly by consumer age and income. Consumers age 25-34 for example, actually chose location over cost as a leading criteria. Conversely, consumers age 45-54 were more than twice as likely to select cost as a primary willingness-to-pay variable than all non-cost related variables combined, as did consumers with annual income levels of <$34K.

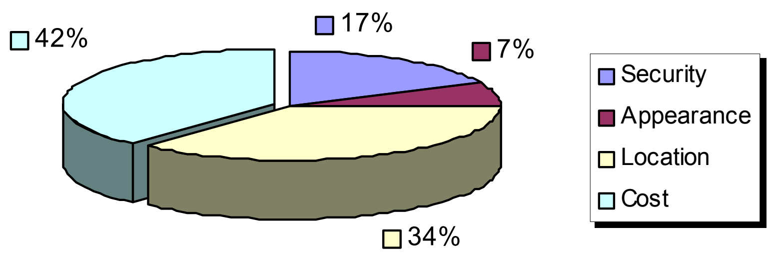

Figure 2: *Consumer Cost Rank With Non-Cost Related Willingness-To-Pay Variables.*

Once the willingness-to-pay influence of cost had been isolated, the importance of different types of cost structures could be further evaluated. Again, willingness-to-pay would most likely be influenced by utility savings that would provide some minimal attractive rate of return, justifying some added cost investment. As shown by Figure 3, total costs and monthly outlays were most important to consumers (34% and 27% respectively).

Table 1: *Sample Energy Reduction Of Bid Alternates Selected And Prioritized By Optimal SIR In Orlando, FL Using 34,000 Cooling Degree-Hours (CDH) And 700 Heating Degree-Days (HDD). Energy Reduction Of Bid Alternates Modeled Individually Compared Energy Reduction Of Bid Alternates Modeled Together Using Minimal MEC Baseline Conditions (Note: 1,000 Gallons or "Kgal" = 2,642 Liters)*

High-Performance Bid Alternates	Item Unit	Energy Reduction - ΔMMBtuh/unit/yr (Bid Alternates Modeled Individually)		Energy Reduction - ΔMMBtuh/unit/yr (Bid Alternates Modeled In Series)		Water Reduction - Δkgal/unit/yr	
		Item	**Cumulative**	**Item**	**Cumulative**	**Item**	**Cumulative**
Low-flow shower fixtures	2ea	1.40	1.40	1.40	1.40	4.40	4.40
Low-flow, high-efficiency dishwasher	1ea	2.90	4.30	2.90	4.30	4.50	8.90
3.5 COP air-source heat pump	1ea	5.19	9.49	5.19	9.49	0.00	8.90
Low-flow clothes washer	1ea	0.70	10.19	0.70	10.19	5.65	14.55
Indoor compact fluorescent	15ea	1.50	11.69	1.20	11.39	0.00	14.55
Solar DHW	1ea	10.50	22.19	6.92	18.31	0.00	14.55
DBL/LoE vinyl windows	250sf	7.80	29.99	6.50	24.81	0.00	14.55
R-13 batt wall insulation	2000sf	1.01	31.00	0.73	25.54	0.00	14.55
R-38 batt ceiling insulation	2000sf	1.08	32.08	0.80	26.34	0.00	14.55

Table 2: *Sample Payback Of Bid Alternates Selected And Prioritized By Optimal SIR In Orlando, FL Using 34,000 Cooling Degree-Hours (CDH), 700 Heating Degree-Days (HDD) And 15-Year Analysis Period. Energy Reduction of Bid Alternates Modeled Individually Compared Energy Reduction of Bid Alternates Modeled Together Using Minimal MEC Baseline Conditions (Note Water And Wastewater Factored At $US 3.50 Per 1000 Gallons – 2,642 Liters - For Bid Alternates Providing Additional Water Savings).*

High-Performance Bid Alternates	Item Unit	Added Capital Cost	SIR	Return on Investment (Bid Alternates Modeled Individually)		Return on Investment (Bid Alternates Modeled In Series)		Rate of Return
				Item	**Cumulative**	**Item**	**Cumulative**	
Low-flow shower fixtures	2ea	$64.22	11.7	$751.99	$751.99	$751.99	$751.99	78.1%
Low-flow, high efficiency dishwasher	1ea	$140.00	7.8	$1,094.37	$1,846.36	$1,094.37	$1,846.36	60.2%
3.5 COP air-source heat pump	1ea	$300.00	6.4	$1,931.40	$3,777.76	$1,931.40	$3,777.76	49.8%
Low-flow clothes washer	1ea	$111.00	3.9	$427.75	$4,205.51	$427.75	$4,205.51	45.4%
Indoor compact fluorescent*	15ea	$162.00	3.4	$558.21	$4,763.72	$446.57	$4,652.08	39.6%
Solar DHW	1ea	$1,326.00	3.0	$3,981.88	$8,745.60	$2,575.20	$7,227.28	21.7%
DBL/LoE vinyl windows	250sf	$1,350.00	2.2	$2,902.68	$11,648.28	$2,418.90	$9,646.18	16.8%
R-13 batt wall insulation	2000sf	$249.00	1.5	$375.86	$12,024.14	$271.66	$9,917.84	15.9%
R-38 batt ceiling insulation	2000sf	$311.02	1.3	$401.91	$12,426.05	$297.71	$10,215.55	14.8%
		$4,013.24					**$10,215.55**	

* Assumes 10,000 hour service life, includes replacement cost at 7.5 years.

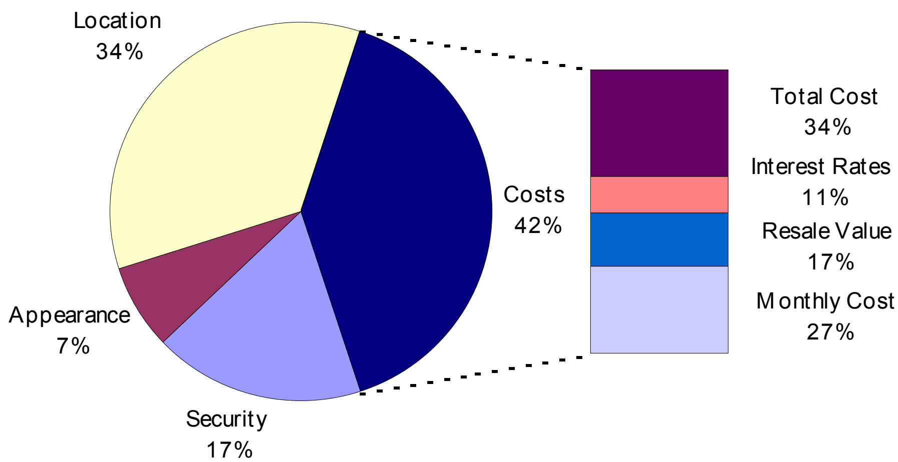

Figure 3: *Frequency Distribution of Consumer Cost Rank by Type of Cost Structure. As Expected, Monthly Costs Were Most Important to Younger, Working New Homebuyers Age 25-54, Whereas Total Costs Are of Significantly Greater Importance to Consumers Age 65+ and the Closely Related Retired Consumer.*

Data shows that consumers were on average, most willing-to-pay for high cost, high return alternatives (42%) when compared to moderate (25%) or low capital cost, low return (22%) alternatives (Figure 4). For all product groups, the observed trends were consistent and statistically significant. However, the data shows a reduction in willingness to pay as investment costs increases and savings-to-investment ratio (SIR) decreases. Low-flow water fixtures with an added investment cost of $US 400.00 and savings of $US 290.00 per year, or a SIR of 11.7, were chosen by nearly half of the respondents surveyed. By contrast, high-performance HVAC and window alternatives having added investment costs of $US 1,300.00 and $US 1,400.00 per year, or a SIR of 6.4 and 2.2 respectively, were selected by little more than one-third of respondents.

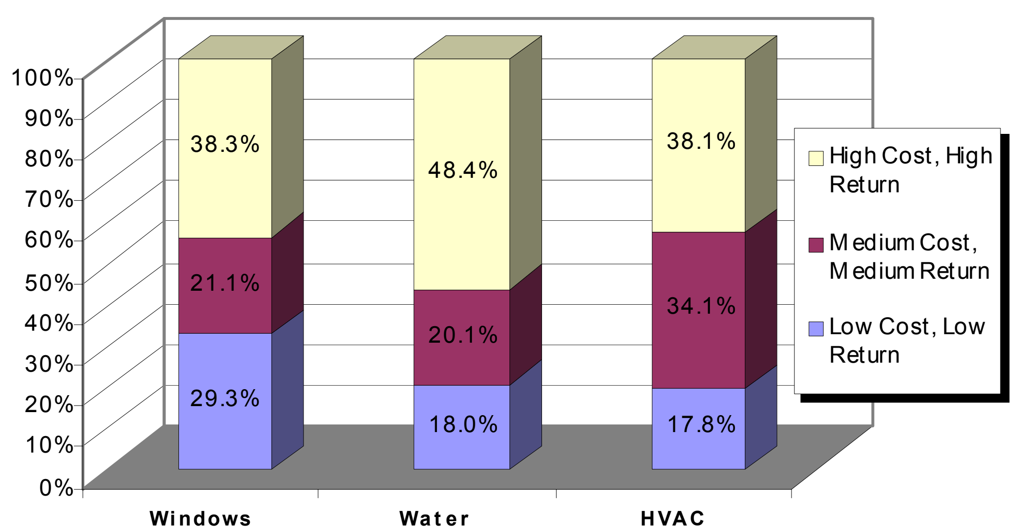

Figure 4: *Consumer Willingness-To-Pay For Low, Moderate and High Cost, High Return Sustainable Window, Watergy and HVAC Alternatives.*

Once aggregate willingness-to-pay averages had been determined from the population as a whole, crosstabulations were used to determine if significant differences existed among different demographic groups of consumers. If significant differences were found to exist among specific demographic groups, then high-performance bid alternates could be more accurately selected to match the payback preferences of those demographic groups within the developer's or builder's target market.

An analysis of consumer age for example, revealed that willingness-to-pay for high cost, high return alternatives increased to as high as 52% as consumers approached middle age (35-45) and steadily decreased thereafter to 37% by age 65. Consumer interest in low cost, low return window, low-flow and HVAC alternatives remained relatively un-changed between age groups, averaging between 20% and 30%. For all age groups however, interest in high cost, high return alternatives remained distinctly above both low and moderate cost, moderate return alternatives, except for consumers <35 years of age. This age group demonstrated a significant willingness-to-pay for moderate alternatives over high cost, high return alternatives.

Maximum return-on-investment over the product life-cycle was also found to be another influential variable affecting consumer willingness to pay. Survey results find that willingness-to-pay for each alternative is positively correlated to the actual dollar amount of maximum return-on-investment. Willingness-to-pay was also correlated to increase in capital cost recovery, meaning willingness-to-pay decreased as the time necessary to recover the capital cost investment increased (Figure 5).

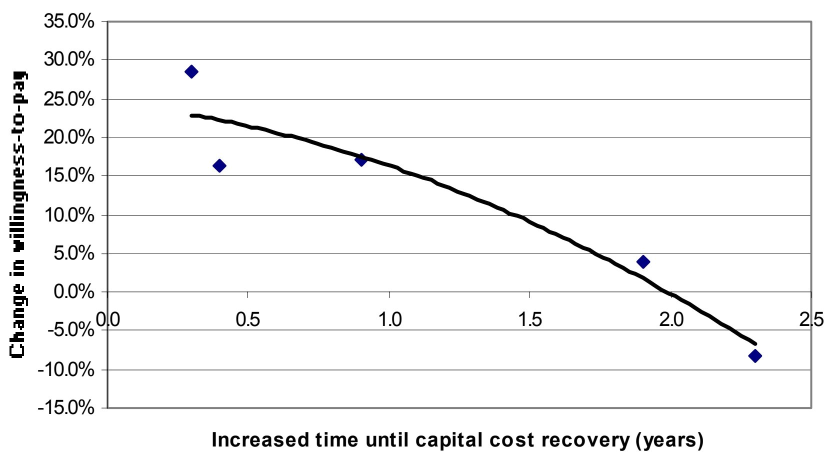

Figure 5: *Change in Willingness-To-Pay Relative to Capital Cost Recovery.*

Realizing that hard costs alone may not guide the decision to invest in green building products, it was necessary to assess the consumer's willingness-to-pay for "soft" cost benefits, or the social or ecological benefits that accrue to the community and the environment in part by the consumer's investment in more efficient, less wasteful alternatives, even though the consumer would not necessarily realize a monetary return on that investment.

Results indicate that willingness-to-pay for soft cost benefits excluding hard cost returns vary widely from 33.8% to 61.1, presumably as a result of either differences in familiarity with the advanced alternatives presented by the survey or the level of "soft" cost benefits consumers perceive to be provided by the respective alternatives (Figure 6). Regardless, consumers appear to have a preference for selecting alternatives that do not necessarily demonstrate a positive hard cost payback but protect the human health and the health of the environment.

When comparing those approximate 40% of consumers that were unwilling to pay for soft cost benefits, more than 80% of them chose either a low, moderate or high cost, high return bid alternative when given the option to decline any green building upgrade investment. Overall, more than 60% of consumers were likely to invest in ultra-high efficiency technologies that still today, remain very costly and may not provide the "payback" possible with more mature, commercially available high-performance systems. Notable exceptions are consumers age 55-65, who were significantly less likely to invest in green building alternatives for soft cost benefits alone.

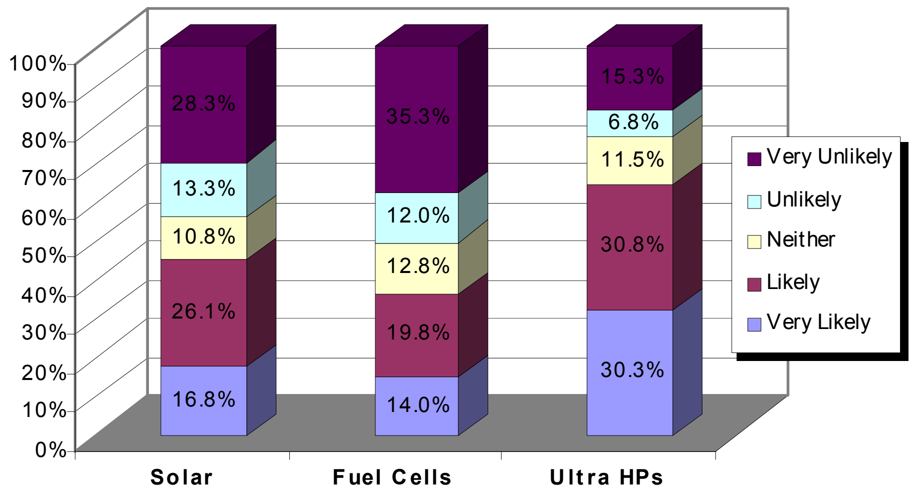

Figure 6: *Consumer Willingness-To-Pay for "Soft-Cost" Benefits Excluding Tangible ROI.*

CONCLUSIONS

In summary, respondents age 45-54 in professional occupations with annual incomes greater than $65K are nearly twice as likely to invest in high performance green building bid alternates than respondents less than 35 years of age having incomes of $US 34,000 or less. More than 90% of all respondents were willing to invest in green building bid alternates for either hard or soft cost benefits. From these and several other statistically significant relationships discovered by the performance models and consumer surveys, The University of Florida Center for Construction and the Environment has performed numerous feasibility studies for private development ventures and government agencies throughout the U.S. in an effort to competitively market viable green building technologies specific to the demographic make-up of various consumer groups.

ERRATA

To view the Errata associated with this article, click here.

DISCUSSION

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