Well Beyond Energy Codes: The Green Points Program in Boulder, Colorado

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ABSTRACT

This paper documents energy savings and environmental impacts of the unique "Green Points" Program in Boulder, Colorado. Under the program, new dwelling units outperform by an average of 30 percent those that merely meet International Energy Conservation Codes (IECC). Beyond the requirement to meet IECC 2000 energy codes, new homes, additions and remodels over 500 square feet are required to incorporate measures associated with a minimum number of 'Green Points'. Green Points are awarded when measures are beyond-code improvements in insulation, windows, and the Heating Ventilation and Air Conditioning (HVAC) system by using REScheck® energy code software. Other measures include: using recycled-content materials; simplicity of design to minimize land use; water conservation and xeriscape landscaping; energy-efficient plumbing (e.g., demand water heaters; devices for saving hot water); hard-wired Compact Fluorescent Lighting (CFL) lighting; energy-efficient appliances; natural cooling measures; auxiliary HVAC measures (e.g., heat recovery ventilation, hydronic heating, radiant slab, whole house fan); and solar (hot water, both active and passive space heating, and photovoltaic).

The number of Green Points required is a direct function of the size of the structure, so larger homes must be particularly energy efficient and environmentally responsible to receive a building permit.

In evaluating the consequences of the Program, the authors developed a hybrid methodology for quantifying the range of benefits flowing from the number of Green Points indicated on the builders' permit applications, while accounting for interactions between measures to avoid overstating savings. The results were integrated into an Access® database that calculates and displays aggregate energy and environmental savings as well as information disaggregated by measure for all dwelling units built, added to, or retrofitted under Boulder's Green Points Program. The resulting information is expressed in various graphic and tabular forms so that citizens, homeowners, builders, planners, and policy makers may understand the Program's effects.

The average dwelling unit built under Boulder's Green Points Program has 1,695 square feet of floor space and saves 1,218 kWh of electricity, 298 therms of gas and 11,562 gallons of water with respect to a "just meets IECC 2000 code" dwelling of the same size.

It is hoped that other communities would emulate the best features of Boulder's pioneering efforts and share practical wisdom about tactics that prove to be particularly effective in achieving energy-efficient homes that also conserve water and building resources.

Introduction

The city of Boulder, Colorado, is nestled into the beautiful landscapes of eastern foothills of the Rocky Mountains. Boulder has a history of progressive ordinances that demonstrate the city's commitment to environmental sustainability, as local governments have become increasingly interested in improving the quality of life, for the greater good of the community. Since residential construction is the single most consumptive land use type in both urban and suburban settings, it is no surprise that the city of Boulder was the first municipality in the country to approve and implement a mandatory residential green building program. The city's aim in implementing the Green Points Program was to promote and enforce residential construction that is cost competitive, healthy and comfortable to live in, more energy efficient than code, and as easy on the environment as possible.

Policy Creation

In the late 1970's when energy conservation was becoming a national concern, the city of Boulder received a grant from the Department of Energy to perform an energy audit related to community sustainability. The audit revealed that Boulder's residential sector accounted for 39.5 percent of the energy use. Residential dwelling units were categorized into five types, with single-family detached homes in Boulder comprising about 54 percent of the housing stock, consuming 74.1 percent of the residential sector's total energy use.

As a result of this audit, the Energy Options program was developed and implemented in the early 1980's to address energy and water conservation in residential construction. Throughout the next two decades, energy codes were improved and catching-up to the city's conservation requirements. Staff was directed to upgrade the program, which was adopted and renamed the Green Points Program in 1996.

Program Implementation

Building professionals assisted in the development of the Green Points Program criteria, which improved the existing energy and water conservation measures and expanded to a full-scale green building program. The primary focus was to provide greater energy efficiency, reduce pollution, create healthier indoor air quality, limit water usage, preserve natural resources, and improve structure durability while reducing maintenance.

A number of considerations were taken into account in designing the program. These included specific conditions of the local geography, heating and cooling degree days, moisture conditions, indigenous building materials, availability of green technologies and recycled-content products, and construction material recycling infrastructure. The building professional group that designed the Program decided that since certain features have more value or greater cost than others, based on environmental considerations, the point system should reflect these differences. These are exhibited in the Program's checklist. One example is the installation of a whole-house fan (2 points) compared to a heat recovery ventilation system (8 points).

The Green Points Program defines nine categories of green options and includes a tenth category, "innovation". Since building science techniques and technologies are constantly evolving, the Program provides an opportunity for architects, builders and engineers to be creative and receive Green Points reflective of their ingenuity. The ten categories are:

Construction, Demolition and the use of Recycled Materials; Land Use and Water Conservation; Framing; Plumbing; Electrical; Windows and Insulation; Heating, Ventilation, and Air Conditioning; Solar; Indoor Air Quality and Interior Finishes; and Innovative Points. Under these ten categories, there are 71 measures to choose from, adding up to a maximum of 338 total points.

The basic rule for new dwelling units is that they must meet the requirements of International Energy Conservation Code (IECC) 2000 plus earn 50 green points for dwelling units of up to 1,500 square feet; 65 points for dwelling units of 1,501 to 2,500 square feet, and 65 points plus 1 point for each additional 50 square feet above 2,500 square feet. A similarly-tiered system applies to interior remodel and addition projects larger than 500 square feet (City of Boulder 2001).

Program Performance and Evaluation

The Green Points Program was conceived as a mechanism for encouraging the overall social, economic and environmental good of constructing new and remodeled homes whose negative environmental consequences over the life of the structures are as low as possible.

In practice, this common good has a number of specifics: design simplicity; the use of recycled, engineered, and low-wood content materials; incorporating landscaping and plumbing tactics that limit water use; adopting energy efficiency measures for saving both gas and electricity; and incorporating renewables to supply energy for space and water heating as well as for electricity. Since many of these elements are different from one another, it is hard to imagine, much less design, a single methodology for assigning Green Points for all possible measures. Whereas one may calculate the incremental savings achievable by a more efficient furnace and weigh its energy savings potential in light of doubling the R-value of attic insulation, it is difficult to weigh the value of employing recycled 2 x 6's in the solar space and foreswearing Kentucky bluegrass in the yard in favor of cacti indigenous to the Front Range of the Rocky Mountains. Accordingly, the Program designers relied on intuition, educated common sense, and some rules of thumb incorporated in various energy code documents to assign Green Points to measures.

After the first two years of implementation of the upgraded Green Points Program, city staff decided to better estimate the savings achieved through the program. The initial task involved assigning savings associated with Green Points (Kinney 2003), a job that in retrospect should have preceded the assigning of points. At the outset, it was decided to separate the Green Points into two classes: those whose environmental and energy consequence are extremely difficult to quantify, and those which could yield defendable estimates of the savings of water, natural gas, and electricity, where the savings of the latter two commodities are correlated with avoiding the release of greenhouse gases and other undesirable substances into the environment. In the case of water, savings are achieved both directly at the site (for example, through xeriscaped landscaping, low-flow watering devices, and water-efficient appliances) and at the power plant (source) when electricity is saved at the home (site). Most of Boulder's electricity is generated by coal-fired power stations which use an estimated 0.65 gallons of water per kWh generated. Accounting for gas-fired power plants and other smaller contributors to the mix of electric generation, we estimate that water savings at the source correlates to 0.5 gallon per kWh saved at the site.

Toward quantifying energy-related measures, we relied primarily on standard engineering techniques derived from the four handbooks of the American Society of Heating, Ventilating, and Air-conditioning Engineers (ASHRAE) and other related literature. Where appropriate, we also made a number of runs using Energy 10 software to estimate by-measure savings and to quantify interactivity between measures. To represent typical new dwelling units in Boulder, we used a "canonical" 1,800 square foot, two-story home with both a basement and a crawl space with evenly-distributed glazing representing about 15 percent of the surface area of the home, normalizing results on a per-square-foot basis.

To date, approximately 80 percent of applications for building permits make use of REScheck software. The software produces a report that expresses results as an overall heat transfer coefficient for the dwelling units (UA) and the percentage by which it is lower or higher than the UA of a dwelling unit of the same size that would just meet code. One green point is earned for each percentage point by which the energy efficiency of the proposed dwelling unit exceeds that of a just-meets-code dwelling unit. Importantly, the methodology used by REScheck to produce an overall UA accounts for interactivity between measures affecting heat loss.

Interactivity between other measures had to be handled differently. For example, using energy-efficient lighting or refrigerators has direct electric energy savings, but also results in less dissipated heat within the conditioned envelope. Therefore, these measures tend to lower the cooling load and raise the heating load. Since the electricity typically used to meet the cooling load costs substantially more than the natural gas used to meet the heating load, these secondary effects of installing energy-efficient lighting and appliances tend to achieve net dollar savings in dwelling units that employ air conditioning. In all events, it's important to quantify their consequences.

The case in which solar systems are used to offset some portion of space heating is more complicated. Solar is more effective as dwelling units are better insulated and tighter, but solar systems also make the investment in more efficient heating systems less attractive. (At the limit, when a dwelling unit is 100% solar, investments in heating systems have an infinite payback period.) Boulder's Green Points Program rewards solar builders with 6 points for a 20% solar fraction, 12 points for a 40% solar fraction, and 20 points for a 60% solar fraction. To account for interactivity between measures, we first calculate the annual space heating energy use after other (non-solar) beyond-code Green Points measures have been accounted for, then claim space heating savings as the solar fraction of that remaining amount.

For all measures where quantification was possible, formulas or look-up tables were developed from the analyses of net water, electricity, and natural gas savings flowing from the Green Points claimed in approved building permit applications. These were integrated into an Access™ data base formatted to facilitate the entry of data from building permits and produce savings estimates aggregated in a variety of forms.

Results

Table 1 shows aggregate results from 267 dwelling units (77 single family, 190 apartments) participating in Boulder's Green Points Program during 2003 and 2004.

Table 1. Green Points and Resulting Savings of Electricity, Natural Gas, Water, and Money by Principal Saving Category (n = 267)

Category	Points	Elec. (KWh)	Elec. $	Gas (Therms)	Gas $	Site Water (Gal)	Source Water (Gal)	Total Water (Gal)	Water $	Total $
Appliances	345	58,305	$5,073	-	-	507,150	29,153	536,303	$1,770	$6,842
HVAC	256	66,317	$5,770	379	$292	(23,195)	33,158	9,964	$33	$6,094
Infiltration	480	4,001	$348	5,335	$4,108	-	2,001	2,001	$7	$4,463
Insulation	4,578	49,070	$4,269	53,761	$41,396	-	24,535	24,535	$81	$45,746
Irrigation	333	-	-	-	-	2,553,000	-	2,553,000	$8,425	$8,425
Lighting	250	55,306	$4,812	(1,147)	($883)	-	27,653	27,653	$91	$4,020
Windows	1,658	15,658	$1,362	16,341	$12,582	-	7,829	7,829	$26	$13,970
Other	415	77,493	$6,742	5,604	$4,315	50,000	38,746	88,746	$293	$11,350
Total	8,315	326,149	$28,375	80,273	$61,810	3,086,955	163,075	3,250,030	$10,725	$100,910

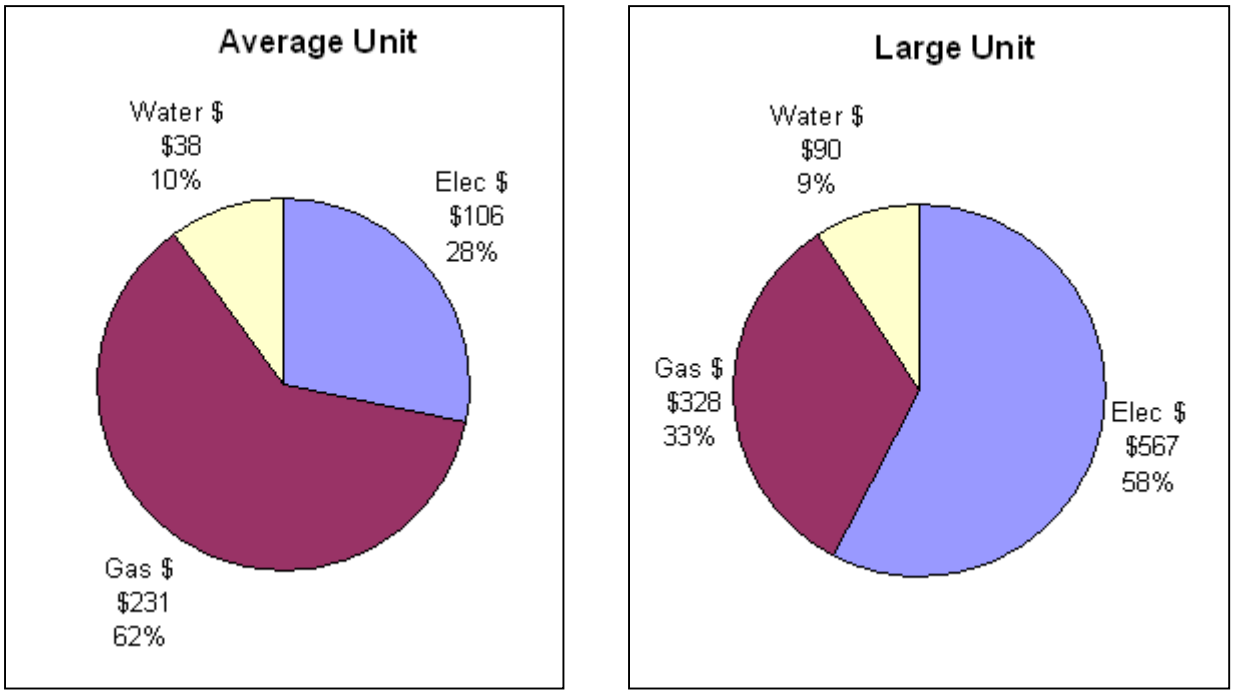
These are savings achieved compared to dwelling units that just meet the IECC 2000 energy code. Note that water savings are achieved at the source (by virtue of electricity savings) and at the site (by virtue of various conservation measures), but cost savings in the water category are counted only at the site. Water savings at the site in the HVAC category are negative because of evaporative coolers, but this is more than made up for by other water savings at the site and at the source.

Table 2 shows savings achieved by an average dwelling unit, whose living space is 1,705 square feet, as well as a large dwelling unit whose living space is 6,031 square feet. Figure 1 illustrates the differences in annual dollar savings.

Table 2. Points and Savings for an Average and a Large Dwelling Unit

	Points	*Sq Ft*	*Elec. (KWh)*	*Gas (Therms)*	*Water (Gal)*	*Elec. $*	*Gas $*	*Water $*	*Total $*
Average Unit	72	1,705	1,222	301	11,562	$106	$231	$38	$375
Large Unit	129	6,031	6,517	426	27,410	$567	$328	$90	$985

Figure 1. Electricity, Natural Gas, and Water Savings Costs for an Average Dwelling and a Large Dwelling



Note that the 1,705 square foot average dwelling had 72 Green Points, seven points more than required by the Green Points Program for new dwelling units between 1,501 and 2,500 square feet. It achieved an annual savings of $375 over a just-meets-code new dwelling, with the majority of the energy savings in natural gas. The 6,031 square foot dwelling achieved an annual savings of $985, 2.6 times the savings of an average size dwelling. Electric savings predominated in the case of the larger dwelling.

Figures 2, 3, and 4 express annual electric savings, natural gas savings, and water savings by the Green Points program.

Note that although lighting savings are quite positive in the case of electricity, they are slightly negative on the natural gas chart, reflecting the need for slightly more heating energy necessitated by less heat flowing from energy-efficient fixtures. Water savings are overwhelmingly achieved by irrigation measures.

Figure 2. Annual Electric and Dollar Savings by Category Achieved by 267 Dwelling Units

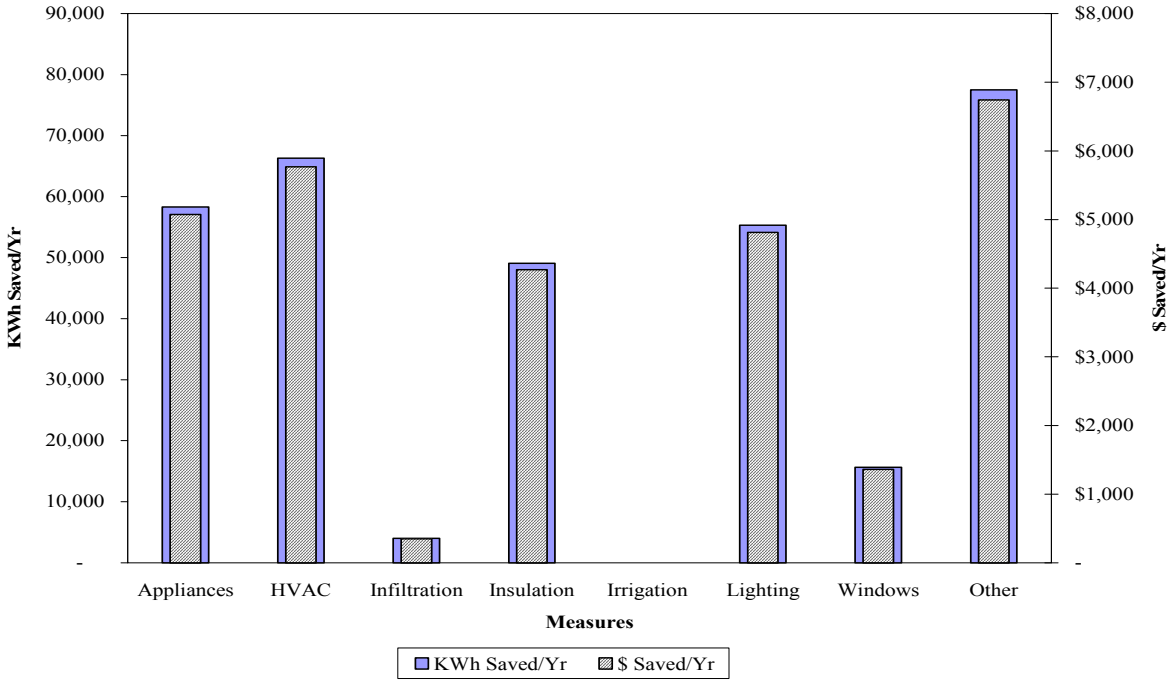


Figure 3. Annual Natural Gas and Associated Dollar Savings by Category Achieved by 267 Dwelling Units

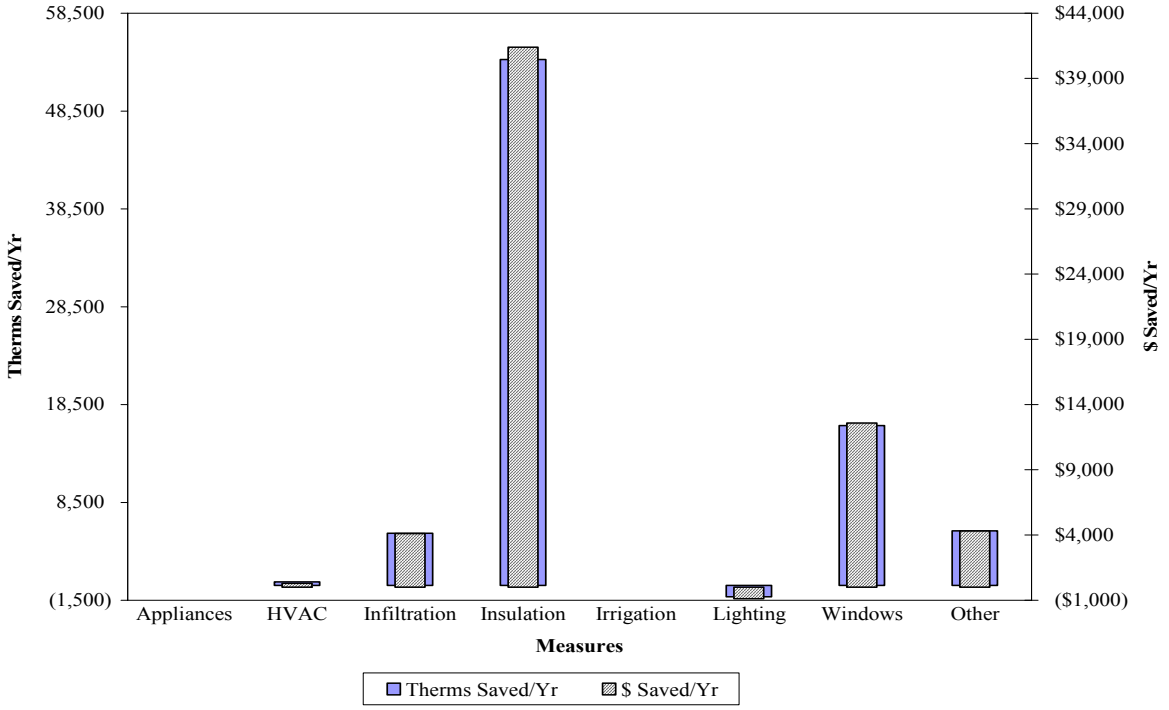
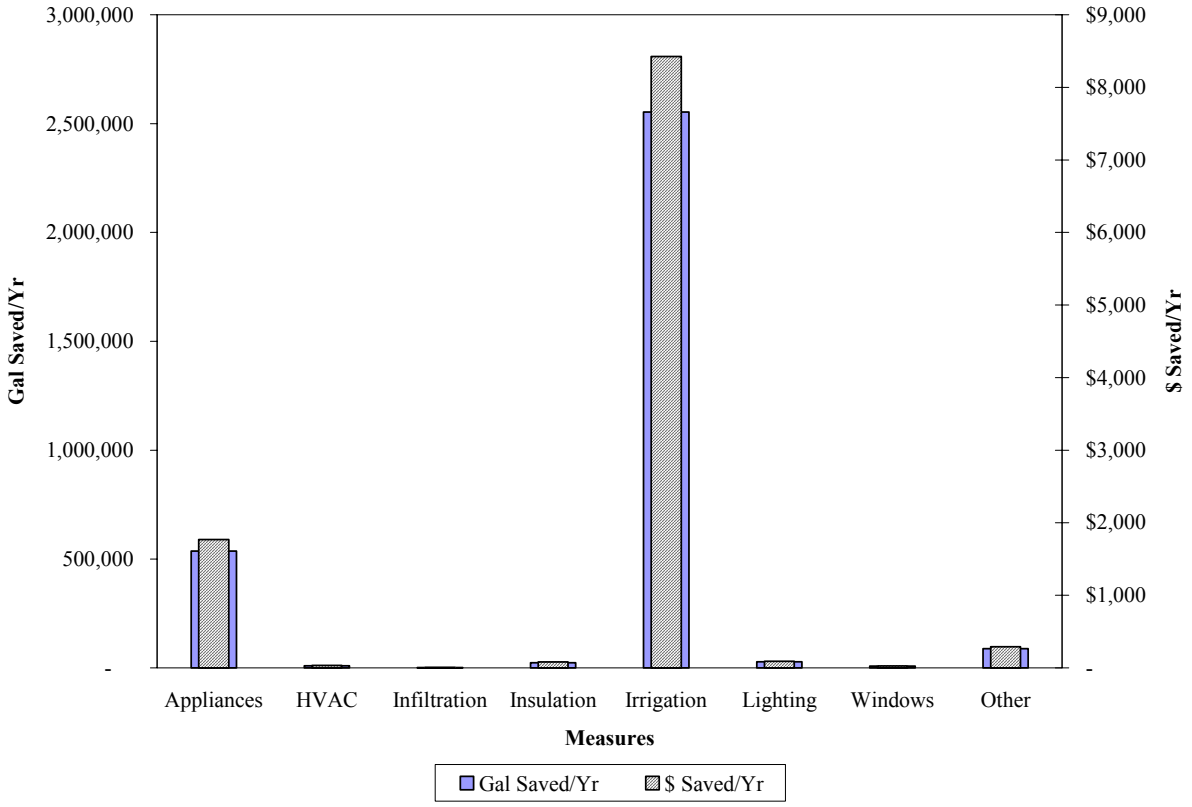


Figure 4. Annual Water and Associated Dollar Savings by Category Achieved by 267 Dwelling Units



Conclusions

The Green Points Program in Boulder has been useful in stimulating the construction industry to build more energy-efficient and environmentally-responsible dwellings than would have otherwise occurred. Builders and codes officials had some rough moments at the outset of the Program, but the system is working and all parties have learned to adapt. The fact that savings in electricity, gas, and water are clear and palpable is important to all parties—homeowners, builders, policy makers, and the larger Boulder community whose city council voted to embrace the Kyoto Protocol accord.

In retrospect, while recognizing that it is important to build on momentum and get a program with good potential on the air as expeditiously as possible, it would have been best to have estimated potential savings before assigning points. This would have resulted in a more judicious balance between categories of savings per point. Fortunately, in most of the categories associated with a large number of points, the savings-per-point ratios are quite similar. There, of course, are exceptions; the lighting measures deserve more points. However, such details will be addressed when the Program takes a moderate mid-course correction, when it will likely integrate IECC 2003 codes into the system. In making mid-course corrections, it is important to avoid making too many and doing it too often. Why? Because it is critical to maintain Program's momentum and success depends on continuous cooperation by all parties to ensure good compliance.

From the point of view of designing a large data base, it would be nice to anticipate everyone's needs and plan for them at the outset. Yet, in the real world it's impossible to work from a precise specification. Therefore, it's critical to stay flexible enough to meet unforeseeable needs while avoiding the temptation to gather all scraps of data whether or not useful for present analytical purposes. Our experience is that asking too much is inevitably disenchanting to those who gather and record data, thereby risking the deterioration of data quality of the key information that really is critical.

We are continuing to gather data on all building permits issued under the Green Points Program and are working to make the data as useful as possible. This involves thinking through how to display data for maximal effect with different audiences. We plan to make judicious use of the web, the local press, school teachers, energy and environmental professionals, the building community, and concerned citizens to promote the valuable results of the Green Points Program—energy-efficient housing stock that is as light on the environment as possible.

We are hopeful that our experiences with Boulder's Green Points Program can be helpful to others who may be interested in emulating the best features of the Program. We are both open to improvement and most willing to share what we've learned.

Acknowledgements

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References

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