AN EVALUATION OF HARVARD'S RESOURCE CONSERVATION INCENTIVE PROGRAM: PAST PERFORMANCE AND FUTURE CONSIDERATIONS

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Abstract

In this paper, we provide a summary of the accomplishments of Harvard University's Resource Conservation Incentive Program (RCIP) in the first five years of its implementation. We estimate that this revolving loan program has yielded a 34% return on conservation investments, with associated decreases in resource usage, ambient air emissions, and water consumption. Although economic returns have been significant, participation has declined since the initial rollout of the program and relatively non-technical conservation measures have generally been the focus of RCIP projects. Through surveys of both participating and non-participating facility directors, we determined that lack of knowledge of effective conservation measures and limitations in staff availability were the key barriers preventing more extensive participation. Increased flow of information, through such actions as frequent facility manager correspondence and independent energy audits of facilities, would be likely to stimulate energy and water conservation efforts in the future.

Introduction

The Resource Conservation Incentive Program (RCIP) was initiated in 1993 to provide a financial incentive for energy and water conservation investments at Harvard University. The RCIP established a $1.5 million revolving loan fund available to all Harvard-affiliated facilities. Any proposed project is required to have a payback period of five years or less, based on estimates of the cost of installation and the reduced operating and maintenance costs. The estimated annual savings are used to determine the annual loan payments, which are made at zero interest until the loan is repaid. Additional savings then accrue in the operating budget of the facility for the lifetime of the conservation investment. Thus, the RCIP provides a financial instrument to allow facilities to undertake conservation efforts without impacting their capital budgets, guaranteeing no adverse financial impacts throughout the life cycle of the investment if the conservation measures perform as anticipated.

Analytical Methodology

To determine the performance of the RCIP over its five-year tenure, we rely on both financial and resource conservation calculations. For all projects, we use the actual project expense rather than the estimated loan requirement when calculating the financial implications of the project, since this is a better reflection of the return on investment.

The annual financial savings are estimated from the engineering reports and calculations provided to the RCIP. Since there is no reasonable way to calculate the actual savings following the conservation measure (given variable climate, occupant behaviors, and loads), we rely on these pre-installation estimates. Any discrepancies between theoretical and actual performance cannot be captured quantitatively, but are considered in the surveys of facility managers. Similarly, we estimate the annual resources saved using the engineering reports. The resources considered include electricity, water, chilled water, steam, oil, and natural gas.

In our calculations of payback and savings below, we primarily present estimates of the first-year savings. The aggregate savings during the five-year loan window is also calculated, although this term is difficult to compare across projects given different assumptions about the time path of resource prices and usage patterns. Although life cycle savings would be ideal in evaluating the true benefits of a project, estimating the present value of cost savings over the lifetime of the conservation measure, lack of information precludes this analysis.

To estimate the emissions associated with resource use, we rely on a variety of sources. For electricity, we use the 1995 annual average marginal emission rates of the New England Power Pool (NEPOOL; Carlin *et al.*, 1996). The marginal emission rate is appropriate, given the relatively small changes in electricity use in comparison with the aggregate NEPOOL load. For steam and chilled water, the emission rates depend on the location within the Harvard campus. For facilities at the Longwood Medical Area, these resources are provided by the Medical Area Total Energy Plant (MATEP), a cogeneration plant powered by natural gas and fuel oil. To allocate emissions to these outputs, we use an energy flow analysis conducted in a previous study (Levy *et al.*, 1999a). For other facilities, we assume that the steam is produced from #6 fuel oil (150,000 BTU/gallon) at a heat rate of 1,500 BTU/lb of steam and chilled water is produced by electricity at a rate of 0.7 kW/ton (Carter Wall, personal communication). For direct combustion of oil and natural gas, we use AP-42 emission factors for commercial boilers.

Survey Methodology

To determine the reasons for participation and non-participation in the past, we designed a survey instrument targeted at the decision-makers within each facility. This survey addressed a number of issues related to the RCIP and resource conservation decisions in general:

- Factors leading to the decision to participate or not participate in the RCIP
- Modes through which the facility director heard about the RCIP
- Assessments of the performance of past RCIP projects
- Features of the RCIP that encourage/discourage participation
- Anticipated timeline and scope of any future RCIP projects
- Barriers to implementation of new technology
- Estimation of the relative resource efficiency of the facility at present

The surveys were conducted by telephone and took approximately 10-15 minutes to administer. All facility directors were notified about the survey by University Operations Services in advance of their phone interview. The complete survey instrument is available upon request.

Results

Past Performance

During the first five years of the RCIP, 39 projects were proposed. Two of these projects were cancelled, and the two projects proposed in FY98 had not been initiated at the start of FY99. Three other projects did not initiate loans, given a payback period of less than one year; since these projects were completed and provided estimated expenses and annual savings, we include them in our analysis. We therefore focus our analysis on 35 projects.

A significant fraction of these projects were initiated in the first year the RCIP was available, with 26 projects started in FY94 (Table 1). Over half of the funds dispersed were given to projects in this first year, with only 9 projects in the subsequent four fiscal years. Because of the early implementation of many of the projects and the relatively short payback periods, the fraction of the RCIP fund utilized was well under capacity as of the end of FY99 (projected available funds of $950,000).

For these 35 projects, a total of $2.6 million in upfront expenses was incurred, with first-year savings estimated to be $880,000 (Table 2). This represents an annual 34% return on investment and corresponds to a five-year savings of $4.5 million using the baseline time path assumptions given for each project. Other than three water projects, which assume a 10% rate increase per year with constant consumption, other projects assume constant usage and prices for the duration of the loan. For projects that did not provide five-year estimates, we assume constant usage and prices, which may understate the benefits of the conservation measures.

The conservation efforts are also related to reduced consumption of a number of resources, including electricity, chilled water, steam, oil, natural gas, and water. As indicated in Table 2, a large fraction of the monetary savings comes from reduced electricity (55%) and water (31%) consumption. This is closely related to the specific conservation measures selected by the facilities. Although there was some variability in the measures taken across the campus, over half of the projects involved either the installation of low-flow toilets or more efficient lighting (Table 3). Other projects involved a variety of HVAC system improvements and miscellaneous water usage reduction strategies.

The reduced resource consumption can be translated into reductions in air pollution emissions. Emissions estimates are calculated for all resources except water. In total, the RCIP projects yielded an annual reduction of 8.8 million pounds of CO_2, 35,000 pounds of SO_2, 19,000 pounds of NOx, and 2,100 pounds of PM_{10} (Table 4). Additional criteria and toxic pollutants could be estimated as well, but the above pollutants provide an understanding of the relative magnitude of emissions averted. To provide perspective, the annual CO_2 emissions reduction from RCIP projects is roughly equivalent to the annual emissions from 670 average US automobiles (DOE, 1993; Wilson and Morrill, 1996). Due to the large number of projects associated with electricity usage reduction, a majority of all emissions averted was associated with electricity.

For water projects, the 47 million gallon savings cannot be directly translated into environmental benefits, given the difficulty of quantification and the dependence on source characteristics. To provide an idea of the magnitude of this savings, the RCIP-associated water consumption reduction is equivalent to the annual water consumption of 440 average US households. In addition, it is approximately equal to the annual water consumption of an oil-fired power plant with 168 GWh/year output.

Although a comprehensive evaluation of health impacts is beyond the scope of this report, past studies can be used to approximate the reduced health burdens on society as a result of the lowered emissions (Levy *et al.*, 1999a). Briefly, this study constructed a damage function model to link emissions with ambient concentration changes and resultant health effects. As an approximation, we use the mortality and morbidity impacts per pound of emissions that were calculated in this study for the MATEP power plant. Using these estimates, the reduced emissions of PM_{10}, SO_2, and NOx yielded an annual expected risk reduction of 1.3×10^{-3} premature deaths, 2 asthma attacks, and a number of other morbidity outcomes. The premature deaths averted are roughly equivalent to what would be obtained if 1,600 households in a Boston suburb reduced their residential electricity consumption by 10% (Levy *et al.*, 1999b).

If standard economic values are placed on all morbidity and mortality outcomes, the annual environmental health impacts averted through the RCIP total $11,000. With the inclusion of global warming damages using an average value from the literature (Levy *et al.*, 1999a), the total environmental damages averted each year are $26,000. This does not include any environmental benefits of reduced water consumption, which could potentially be greater than the ambient air benefits if upper-bound values in studies evaluating the costs of surface water depletion are used (Rae *et al.*, 1991).

Survey Findings

In total, 16 facility directors were identified as targets for the survey instrument. Twenty-nine of the 35 projects mentioned above were conducted by eight of these facility directors, with the remaining six projects conducted by an individual who is no longer with the university. The remaining eight identified facility directors did not participate in the RCIP at any point during its five-year tenure. Of the 16 individuals, we were able to contact and survey 15 – all eight former participants and seven non-participants.

For the participants, the primary incentive for participating was the financial structure of the RCIP, including the 0% interest and the provision of funding that would not interfere with the capital budget. Only one of the eight participants cited environmental awareness rather than financial gains as their primary incentive. Participants largely heard about the RCIP through the facility managers network, either by participating in the design and initial rollout of the RCIP or through word of mouth at monthly meetings.

Participants were largely satisfied both with the performance of their conservation measures and the RCIP as a whole. All participants indicated that their installed conservation measures performed at least as well as predicted, although one facility director indicated problems with durability (although energy consumption targets were met). The features of the RCIP that were rated well by participants include the overall program structure, the ease of implementation and use, and the importance of a commitment from the highest levels of the university. All participants indicated that they would use the RCIP again if they had appropriate conservation projects and resources to support these projects.

Despite this enthusiastic response, participants detailed a number of barriers that have kept them from proposing additional projects. A majority of participants stated that there are no applicable conservation projects at present, with the "low-hanging fruit" already picked with the initial RCIP projects and other efforts. Lack of staffing and time was also cited as a significant barrier, along with low energy prices and a lack of available technology to achieve short payback periods. Many past participants indicated that they had already done everything that there was to do, and a majority could not come up with a target to consider in future conservation projects.

All non-participants surveyed had heard of the RCIP and were able to define it reasonably, demonstrating that awareness of the program among facility directors is not the major barrier to participation. However, there was some evidence (from participants as well as non-participants) that knowledge of the program existed largely at the facility director rather than the staff level, which may have led to non-participation.

Non-participants cited a broad range of reasons for the lack of RCIP projects in the past. For some smaller facilities, the RCIP was not considered to be worth the administrative effort, and there was a lack of internal capacity to evaluate opportunities. Facility directors at these locations said that the maintenance staff was "stretched too thin to think about the long-term, instead of putting out fires" and had a "sheer inability to take on anything that is more time-consuming than absolutely necessary". Other facility directors agreed with past participants and stated that they lacked knowledge about additional conservation opportunities. One facility director felt that energy and water costs were generally relatively small in comparison to the overall budget, while another stated that he thought the program was no longer funded, indicating a communication gulf.

In general, both participating and non-participating facility directors pointed to information barriers as the primary disincentive for pursuing resource conservation. The first category of proposed solutions center around increasing the flow of information within the university. Harvard is an extremely decentralized university, and a number of facility directors cited the "every tub on its own bottom" philosophy as a barrier to an integrated and systematic approach to resource conservation. Solutions to this problem included reinstating monthly facility manager meetings to discuss ongoing projects at various facilities and establishing an e-mail or newsletter service to inform managers about conservation work around the university. Added information about the relative performance of facilities was also seen as important in stimulating conservation activities, with one director stating directly that "if I was told that other similar facilities spend less [than my facility], I might rethink things." Given that all facility directors who provided responses stated that their facility was either average or above average in resource efficiency when compared to other facilities at Harvard, this information would be anticipated to alter some opinions.

The second set of solutions for information barriers involves bringing outside assistance to facilities. Many facility directors stated that outside energy audits would be extremely useful and well-received, particularly given staffing shortages and lack of knowledge of conservation alternatives. Other directors thought that information and services centralized within the university would be helpful, ranging from university-wide conservation programs to assistance with energy audits and implementation within individual facilities.

Finally, many facility directors felt that resource conservation could be best encouraged by going beyond the scope of the RCIP. There was a strong sentiment that a university-wide mandate for "green buildings" would be necessary to take additional steps, given that there was a perception that most of the projects with short payback periods had already been implemented. As one facility director stated, "[Under the RCIP], you shouldn't spend money on green projects if there is no cost benefit. If Harvard took away the payback period limits and said 'be green', more projects could be feasible." Other ideas included programs that would integrate resource conservation and energy efficiency into the design phase of new projects and programs that would provide grant funding that would not be dependent on quantifiable payback periods (helping with project coordination and non-energy initiatives).

Discussion

Two conclusions are evident from examining the usage of the RCIP over the past five years. First, the number of projects proposed per year has declined dramatically over time, largely related to a significant number of projects initiated in the first year of the program. From the survey responses and the fact that that the average payback time is slightly lower in FY94 (2.6 years) than in FY95-97 (3.5 years), it is conceivable that the "low-hanging fruit" had been plucked in the initial year. Many of the participants cited this phenomenon; however, it seems implausible that all cost-effective conservation projects at a large university would have been determined in such a short period. Since many participating facility directors were engaged in the design of the RCIP, it is possible that this program motivated many conservation efforts that were already on the radar screens of the directors.

The second conclusion is that lack of knowledge about effective conservation efforts is a major impediment to action. The conservation projects proposed within the confines of the RCIP were relatively monolithic, largely considering low-flow toilets and efficient lights. In addition, facility directors indicated that they were largely unaware of additional cost-effective measures that could be taken in their facilities, although some were able to cite clear areas of concern (e.g., old buildings with minimal climate control, no water conservation efforts made in recent years). Although increased communication between facilities would help to some degree, it appears that time and staffing constraints make the provision of outside support and information critical. This could either come from university-wide efforts, such as information provided by the Engineering and Utilities division regarding substantive measures that might be useful for given building types, or from individual audits of facilities.

When considering information gulfs, it is important to keep in mind the substantial differences between facilities. Some facility directors viewed the RCIP as an opportunity to be "environmentally aware" and as "the right thing to do", while others viewed this dimension of the program as "politically correct" and something they "don't spend much time thinking about." Larger facilities might have a greater capacity to fund energy conservation internally, but can also exemplify the fact that "since Harvard is not scraping for money, a lot of good ideas don't get implemented." Facility directors generally had a difficult time evaluating their relative resource efficiency, given the differences in building portfolios (ranging from commercial to residential to classroom to laboratory space). This variability implies that the information provided to facilities needs to cover a number of different topics, ranging from detailed environmental evaluations to simple comparisons between energy conservation investments and other financial instruments.

In addition, there appears to be a need for more substantial publicity about the RCIP. Although all facility directors surveyed had heard of the program, one was not aware that it was still funded, and there is anecdotal evidence that staff knowledge of the program is far less substantial. Promotion of the RCIP could potentially involve not only the arguments about the risk-free returns on investments, but also an environmental argument within the context of reducing the environmental footprint of the university. Multiple facility directors felt that a university-wide mandate within a larger environmental framework would encourage more extensive resource conservation.

The past performance of investments within the RCIP demonstrates the substantial financial gains available. Although it is difficult to evaluate the total benefits of the RCIP without knowing the lifetime of the conservation measures, the estimated 34% return on investment is substantially higher than could be expected from any financial vehicle. Since many of the conservation efforts involve the installation of hardware into facilities with long expected lifetimes, the projects would likely recoup many times their initial investments in reduced operating costs. Considering only the five-year duration of the RCIP, it is estimated that nearly double the aggregate quantity of loans has been saved in reduced operating costs. In addition, the projects initiated under the RCIP were able to reduce pollutant emissions while providing economic savings. Thus, these initiatives truly represent "win-win" situations.

However, these calculations of benefits should be considered with care. The 34% return is not a goal in and of itself, and is not generally used as a benchmark of program performance. Because of the five-year payback window established in the RCIP, projects that have lower rates of return but might still be economically viable (e.g., long-term structural enhancements) may not be submitted to the RCIP. In addition, projects with extremely high rates of return are often not funded through the RCIP, since loans are typically not required with payback periods of less than one year. Thus, the rate of return is constrained by the program parameters, and is not necessarily indicative of the expected return across a broad portfolio of university conservation initiatives. Thus, the performance of the RCIP might be better measured by the growth in the number of projects supported over time, the growth in participation and awareness, and the annual financial savings, rather than indicators of payback periods or rates of return.

A limitation of our analysis is the inability to compare the actual with the predicted savings from the resource conservation measures. Although the actual performance could not be quantified, facility directors largely believed that the conservation measures achieved or exceeded the predicted performance, indicating that the estimated return on investment is reasonable. Another limitation is the fact that emissions estimates for equipment are based on AP-42 emission factors for average commercial equipment, rather than measured emissions from the specific sources within the university. However, this is likely a minor influence on aggregate emissions, since the bulk of emissions are associated with electricity, for which emission rates are well-documented.

Regardless of these limitations, it is apparent that the measures initiated through the RCIP have yielded both financial and environmental benefits. To achieve future benefits, the RCIP must undergo two types of changes that would encourage broader participation. The first would involve not just providing the economic incentive to conserve resources, but also establishing a framework by which facility managers can learn about conservation methods from colleagues and outside information sources. The RCIP must also provide assistance with staffing concerns and prioritization, either by helping to bring in outside consultants or by building internal capacity at the facilities. The second type of change would go far beyond the original mandate of the RCIP, as the revolving loan concept could be used to foster long-term investments, introduction of resource conservation in the design phase, and environmentally-sound initiatives without quantifiable payback periods. An even broader paradigm would involve the provision of grant money, which could be used to help train staff members, to provide incentives for environmental innovations, and to encourage purchases of new technology.

Conclusions

The Resource Conservation Incentive Program has demonstrated that a revolving loan construct can help motivate cost-effective resource conservation in a university setting. The 35 projects initiated and completed over the course of five years provided an annual return of 34%, with annual savings of $880,000, 8.8 million pounds of CO_2, and reductions in a number of other pollutant emissions and related health effects. However, lack of internal capacity or knowledge of conservation options has led to decreased participation in recent years, with a majority of facility directors unlikely to participate in the short term. Based on the collective wisdom of the facility directors, we recommend the following specific modifications to the RCIP:

- Develop and implement an aggressive program management and marketing plan to reintroduce the RCIP across the Harvard campus
- Improve information flow by reinstating facility director meetings and using electronic media to disseminate and share project updates
- Provide high-level technical assistance to help facilities prioritize among competing projects and determine staffing needs
- Expand program boundaries to include “innovative initiatives” (e.g., campus-wide recycling program, variable-speed drives, digital direct control)
- Publicize project successes to ensure that the RCIP remains on the “radar screens” of key decision makers

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References

C.F. Carlin, Jr., A.H. Aitken, B.W. Bentley, D.B. Damer, J.P. Dwyer, K.M. Goodman, W.E. Nason, J. Scheffer, C.W. Swinton, S.B. Woods, Jr., T. Woycik, J.M. Hickey, and D.G. Robinson, *1994-1996 Marginal Emission Rate Analysis* (NEPLAN, 1996).

J.I. Levy, J.K. Hammitt, Y. Yanagisawa, and J.D. Spengler, "Development of a New Damage Function Model for Power Plants: Methodology and Applications," *Environ. Sci. Technol.*, in press, 1999a.

J.I. Levy, J.K. Hammitt, Y. Yanagisawa, and J.D. Spengler, "Environmental Ramifications of Household Energy Conservation," submitted to *Risk Analysis*, 1999b.

D. Rae, R.D. Rowe, J. Murdoch, and R. Lula, *Valuation of Other Externalities: Air Toxics, Water Consumption, Wastewater, and Land Use*. (RCG/Hagler Bailly, Inc., Boulder, CO, 1991).

U.S. Department of Energy, Energy Information Administration, *Household Vehicles Energy Consumption 1991* (DOE/EIA-0464-91, 1993).

A. Wilson and J. Morrill, *Consumer Guide to Home Energy Savings*. (American Council for an Energy-Efficient Economy, Washington, D.C., 1996).

Table 1: Loans dispersed by fiscal year

Fiscal year	Number of projects	Total loans dispersed (actual expenses when available)
1994	26	$1,365,948
1995	2	$176,634
1996	4	$583,799
1997	3	$472,214

Table 2: Estimated economic and energy savings per year from all RCIP projects

Category	Resource savings	Economic savings
Electricity	4.9 GWh	$490,000
Water	47,000,000 gallons	$280,000
Steam	2,700 MMBTU	$30,000
Chilled water	14,000 ton-days	$39,000
Oil	1,400 gallons	$880
Natural gas	610 MMBTU	$51,000
TOTAL		$880,000

Table 3: Types of projects undertaken. Note that numbers do not sum to total, given multiple investments within single projects.

Project type	**Number**
Low-flow toilets	12
Lighting upgrade	11
Low-flow faucets	4
Low-flow showers	2
HVAC: Improve boiler efficiency	2
Electrical energy conservation	1
Installation of cooling tower	1
Reduction of fume hood exhaust air	1
Conversion of refrigeration units from water- to air-cooled	1
Replacement of water-to-waste aspirator systems with house vacuum systems	1
Conversion of water-to-waste equipment to central chilled water	1
HVAC: Addition of localized cooling	1
HVAC: Convert condenser water loop from chilled water to cooling tower	1
HVAC: Installation of heat recovery coils in air handling units	1
HVAC: Improve metering for chilled water	1
HVAC: Replace electric steam generators with gas-fired boilers	1

Table 4: Emissions reductions associated with RCIP projects (lbs/year). This inventory does not include water conserved.

	PM_{10}	NOx	SO_2	CO_2
Electricity	2,000	15,800	35,000	7,800,000
Chilled water	24	2,500	330	360,000
Steam	51	550	220	540,000
Oil	16	75	190	34,000
Natural gas	7	10	0.4	73,000
TOTAL	2,100	19,000	35,000	8,800,000