Retrocommissioning of Two Long-Term Care Facilities in California

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ABSTRACT

Retrocommissioning is becoming increasingly recognized as a cost-effective strategy for improving the performance of existing buildings without major capital investment. This is particularly true in larger buildings that operate relatively new equipment and use energy management control systems.

Over the past year and a half, the Institute for Market Transformation (IMT) and Portland Energy Conservation, Inc. (PECI) undertook a project funded by Pacific Gas and Electric (PG&E) to reduce energy use in the long-term healthcare sector, the fourth largest energy-consuming commercial building sector. Retrocommissioning was selected as a promising approach because of its links to improved comfort and indoor air quality – results anticipated to be especially beneficial to this sector. However, the initial building selection process revealed that most long-term care facilities have older equipment, relatively small square footage, and unsophisticated controls – characteristics that are typically not ideal for a successful retrocommissioning project.

This paper discusses the value of retrocommissioning for the long-term care sector by describing the process, findings, and results of two demonstration projects in California. The case studies proved successful in achieving significant building energy savings and improvements in indoor air quality despite the barriers to retrocommissioning inherent in long-term healthcare facilities. But the projects had a relatively high cost per square foot. Our analysis of the demonstration projects includes a discussion on whether retrocommissioning is a good fit for smaller buildings with less sophisticated controls and ways that the retrocommissioning process can be modified to meet the needs of this type of facility.

Introduction

The commissioning of existing buildings, referred to as "Retrocommissioning" (RCx), has gained prominence as a cost-effective strategy for improving energy performance. It is an independent process that takes place after construction, and is applied to buildings that have not previously been commissioned. "Retrocommissioning ensures system functionality. It is an inclusive and systematic process intended not only to optimize how equipment and systems operate, but also to optimize how the systems function together." (Haasl & Sharp, 1999)

RCx is valued not only for the magnitude of energy savings attainable without major capital outlay, estimated at between 5 to 15 percent of energy consumption (Haasl & Sharp, 1999), but also for the range of non-energy benefits commonly associated with this approach.

Depending on the scope of the process, these can include improvements in thermal comfort, lighting properties, indoor air quality, and documentation of building operations and systems.

It was for these benefits that the Institute for Market Transformation (IMT) and Portland Energy Conservation, Inc. (PECI) identified RCx as an effective strategy for reducing energy use in the long-term healthcare community. Buildings that operate around the clock, housing people in fragile health, seemed positioned to benefit from the whole-building results of RCx, perhaps more than any other sector.

Background

The long-term care (LTC) industry is comprised of approximately 17,000 buildings nation-wide (AHCA, 2001). The sector encompasses a variety of facilities – skilled-nursing (SNF), residential care (RCFE), and intermediate care for the developmentally disabled (ICF/DD). Of California's over 1400 facilities, 95 percent are classified as SNFs. These facilities, much like hospitals, must operate continually throughout the year. This level of operation, an unchangeable factor, is reflected in their high energy consumption. The U.S. LTC sector consumes 62 billion kWh of electricity annually (EPA) – a level of demand equivalent to the production of approximately 44 million tons of carbon dioxide per year.[1]

While several factors are likely to contribute to the high level of energy use in LTC buildings, the most critical may be their dual nature. These facilities are required to meet both the medical and day-to-day living needs of residential patients for extended periods of time and, therefore, operate a variety of equipment and appliances. Although LTC is a commercial sector, they range in size from small houses caring for six residents to large buildings housing well over 100. These facilities seem to bridge the gap between commercial and residential categories, while not quite fitting into either one. The dilemma with this circumstance lies in obtaining targeted information specific to the needs of LTC facilities. Information on energy efficiency for office buildings does not apply any more than recommendations for residential housing. For example, temperatures cannot be adjusted to reduce equipment operation during the nights and weekends and, if requested by a resident, regulations require temperatures to be set at excessive levels. It is unlikely that facility administrators are willing and able to pick apart educational material to extract that which applies to their buildings.

An additional, and equally important, barrier to energy efficiency for this sector is their lack of energy code requirements. Under the U.S. Social Securities Act, the Centers for Medicare & Medicaid Services (CMS) ensures that all providers of such programs adhere to minimum health and safety standards. In California, the CMS designates the Office of Statewide Health, Planning, and Development (OSHPD) with oversight for all hospitals and other healthcare facilities. At the same time, these buildings are exempt from the state energy code – Title 24. Although OSHPD enforces its own standards, these fall far short of achieving the energy efficiency level possible through compliance with Title 24. Guidance on energy use is not offered through OSHPD. In fact, a disincentive is created by requiring inspections, fees, and additional paperwork when facilities upgrade equipment which is not needed when equipment is replaced by identical products.

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[1] Calculated using the 1998 national average of 1.4203 lbs CO_2/kWh

RCx holds the possibility of multiple benefits for LTC facilities and at first glance is an attractive approach to reducing energy usage. The focus on operations and maintenance (O&M), rather than capitol improvements, avoids first costs that these facilities may not be in a position to allocate and circumvents regulatory red tape. The long-term reduction in operating costs will also have a significant financial impact on LTC facilities. OSHPD data[2] for 1998-1999 show that these costs for facilities range, on average, from $81,358 to $245,447 annually. In addition, expected impacts on the indoor environment, such as improved air quality, will likely benefit residents with compromised immune systems, as well as those confined to the building for extended periods of time. Finally, the cost savings will assist an industry that is typically short of funding and may contribute to the installation of energy efficient-equipment and other building improvements.

Facility Selection

A market assessment of over 100 LTC facilities within PG&E's service-territory, during the initial project stages, provided information that identified potential demonstration sites. We gathered information on size and occupancy, administrative priorities, equipment type and age, barriers to energy efficiency, and energy-related improvements. These were all factors relevant to a successful RCx project. We wished to select two buildings that would generally represent the range of sizes found in the area. The final sites were also to be in different locations to maximize our impact on the community and provide an opportunity to analyze diverse climatic conditions. Each facility that expressed interest in participating was carefully evaluated against the criteria for RCx.

The results of this analysis were not encouraging. First, the size of facilities, as indicated by number of patient beds, was smaller than what is usually considered cost-effective for RCx. Seventy-five percent of facilities reported under 100 residents and were estimated to be about 30,000 square feet. In the end, we chose two facilities with 99 and 150 residents, respectively, to represent the middle and upper ranges of LTC facility sizes in Northern California.[3] While energy and maintenance costs were high, equipment was often decidedly past an age where significant gains in efficiency could be expected without replacement. There was also an overwhelming lack of sophisticated technology in the form of lighting controls or EMCS present in facilities. In light of this information, which despite its inappropriateness for RCx was representative of the LTC sector, we fell to our other criteria in choosing facilities.

It was essential that the administrative staff of the demonstration facilities satisfy three specific qualifications – strong interest and support for RCx, concern about occupant comfort and other non-energy benefits, and ability to correct deficiencies found during RCx (with in-house staff or by hired contractors). Staff at the selected sites were concerned about patient comfort and expressed the ability to pay for work needed, but were chosen primarily for their strong interest, if not excitement, about participating.

[2] The Healthcare Information Division (HID) of OSHPD collects and disseminates data from licensed health facilities in California. See http://www.oshpd.state.ca.us/hid/infores/index.htm

[3] Facilities were grouped into 3 size categories - those with under 50 patient beds were deemed "small," those with between 50 and 100 beds were deemed "medium," and those with over 100 beds were deemed "large." This breakdown resulted in approximately 25% as small facilities, 50% as medium facilities, and 25% as large facilities.

The following information was known about the facilities when selected for RCx:

Meadowood Nursing Center ("Meadowood")

- Location: approximately one hour north of San Francisco
- Equipment: 15 rooftop package units, ranging from 3 to 5 tons, 9 years old, possible economizer; no lighting controls; no EMCS; no programmable thermostats
- Size: 30,000 square feet
- Vintage: 1992

Wagner Heights Nursing & Rehabilitation Center ("Wagner Heights")

- Location: approximately forty-five minutes south of Sacramento (Stockton area)
- Equipment: 20 rooftop package units, ranging from 3 to 10 tons, 11 to 12 years old; no lighting controls; no EMCS; no programmable thermostats
- Size: 45,372 square feet
- Vintage: 1986

Methodology

RCx at both facilities followed four-stages – investigation & data collection, data analysis, implementation of recommendations, and verification of energy savings. Below is a description of that process.

Investigation & Data Collection

Building documentation, including equipment lists, system schematic drawings, and 12 months of utility billing data, was requested from both facilities. However, only billing data was available prior to the following site visits, allowing only a basic assessment of energy usage at that time. During December 2000, project engineers spent two days at each facility for an initial site visit. Activities included a night walkthrough, interviews with staff, equipment inspections, and analysis of data gathered on site. Neither building had a central automation system so data loggers were used to monitor equipment usage. Four-channel data loggers monitored five HVAC system temperatures and operation in Meadowood and seven in Wagner Heights. In addition, at Wagner Heights, light loggers were used to measure interior light levels in the employee lounge, shower rooms, day room, dining room, and kitchen areas. Occupancy patterns were monitored in the employee lounge and dining room areas. Some manual testing was also performed to augment information provided by the data loggers. At Meadowood, engineers examined the HVAC control wiring and manipulated space temperature setpoints to test economizer operation. At Wagner Heights, outside air flow, air flow leaks in the ductwork, and motor voltage and current for the supply and booster fans were measured manually.

Data Analysis

A building model was created for each facility using the software analysis tool EZSim.[4] To provide an additional level of confidence in the baseline provided by EZSim, all baseline loads were calculated by hand in an Excel spreadsheet, to within 5% of existing energy usage, and compared to the values provided by EZSim. Then, the inputs to the EZSim model were adjusted until both methods were reasonably close. This allowed development of an equipment end-use profile and overall building energy use index (EUI). Trend analysis was used to validate existing energy usage and identify opportunities for potential savings.

Energy savings were calculated using customized spreadsheets and then validated with the building model. These calculations included a 15 percent reduction in estimated energy savings to account for interactive effects between measures implemented simultaneously. Cost savings were determined for each recommended measure, using the average electrical energy cost which was calculated by dividing the total monthly cost (including demand costs and taxes) by the monthly consumption. Project costs were all estimated from the data under the assumption that facility maintenance staff would complete the installation or be available to assist a contractor with implementation.

Implementation of Recommendations

In March 2001, we provided the facility owners with a RCx analysis report that detailed all findings and recommendations. Owners were then responsible for selecting which measures to implement and for securing necessary permits and approval from OSHPD. We recommended that the facility maintenance staff implement all measures within their capability and hire outside contractors, if needed, to install the rest. Most facilities of this size have in-house facility staff, of one or two people, who perform most equipment operation and maintenance practices to keep operating costs down.

Verification of Energy Savings

The measurement and verification techniques used followed the IPMVP (International Performance Measurement and Verification Protocol) Option C – Whole Meter Approach (DOE, 1997). Total energy savings for the facility were verified by comparing the post-retrocommissioning utility bills with bills for the same months before the study. The monthly usage was normalized to account for variations in the length of billing cycles. Changes in weather or facility use were taken into consideration in analyzing the graphs.

Baseline Facility Descriptions

Billing data, available prior to the site visits, provided the baseline energy use data shown in Table.1. Meadowood's EUI was calculated at 209,600 BTU/sq. ft. per year and at 163,900 BTU/sq. ft. per year for Wagner Heights.

[4] EZSim is a building analysis tool for energy accounting, auditing and commissioning. More information about EZSim can be found from Stellar Processes, 1033 SW Yamhill, Suite 405, Portland, OR, (503) 827-8336.

Table.1 Baseline Data for Demonstration Sites

	Electric Energy Usage	Fossil Fuel Usage	Annual Total Energy Cost	ECI
Meadowood	639,400 kWh/yr	45,400 gallons propane/yr	$103,100	$3.40/sq. ft. per yr
Wagner Heights	845,300 kWh/yr	45,500 therms natural gas/yr	$112,900	$2.50/sq. ft. per yr

Due to the lack of additional building documentation available, the initial site visit provided the first opportunity to properly assess the state and scope of equipment. Table 2 describes some of the basic systems found in the two facilities.

Key Findings & Recommended Measures

Beyond the baseline assessment of the facilities, the site inspection and discussions with staff uncovered several important findings related to equipment operation. These findings were compiled into a list of energy-saving measures. Many of these were recommended, but the list also included capital improvements and O&M measures that, due to the long payback period, were not suggested at the time of this project. There were also a few recommendations that had no associated energy savings but had potential to impact safety and/or comfort.

Administrative staff from both facilities selected and implemented measures between March and July 2001. The final results, shown in Figures 1 and 2, reflect a reduction of electricity use by 14 percent at Meadowood and by 8 percent at Wagner Heights; cost savings are 8.5 percent and 7.5 percent, respectively. Below are some of the most interesting findings along with corresponding recommendations.

Meadowood

Economizers. The most remarkable finding at facility A was the presence of economizers on 13 of the 15 rooftop packaged HVAC units that had never been connected. The facility was also not equipped with the proper thermostats to allow their operation. Annual cost savings associated with enabling the economizers was estimated at $4,700 and would produce energy savings of approximately 51,200 kWh/year. We recommended that the facility install 2-stage thermostats throughout the facility and connect the economizers. The setback/setup capability of these thermostats also allowed energy savings at times when some areas (the Day Room and Administrative area) are unoccupied. Implementation costs were estimated at $3,600.

Maintenance. The site visit uncovered two significant maintenance issues affecting energy use and indoor air quality. The screen on the laundry exhaust fan was found plugged with lint, reducing the amount of air that was removed from this area. Similarly, the return and outside air filters were completely clogged. This condition can cause the supply fan to work harder and lead to air quality problems as a result of reduced air delivered by the system.

Table 2. Facility Systems

	Meadowood	Wagner Heights
Packaged HVAC Units with supply fan, direct expansion cooling coil, hot air furnace		
Number of HVAC units (Age)	15 (9 yrs. old)	1 ("new") and 19 (11-12 yrs. old)
Total facility cooling load	approximately 57 tons	approximately 102 tons
Estimated cooling efficiency (EER)	8.5 Btu/watt-hour	6.5 Btu/watt-hour
Type of furnace	propane-fired	natural gas-fired
Total facility heating load	approximately 1,520 kBtuh	approximately 1,412 kBtuh
Estimated combustion efficiency	75%	75%
Supply fan horsepower; Total connected load	0.5-2.0 HP; 12.25 HP	0.5-1.5 HP; 11.5 HP
Booster fan supply; Total connected load	none	0.5-0.75 HP; 11.75
Total amount of air; Outside air	22,700 CFM; 27% outside air from 13 fans and 100% outside air from 2 fans	41,665 CFM; 31% outside air
Thermostat heat/cool setpoints	73/75 degrees F (resident & common areas); 68/70 degrees F (kitchen & laundry)	same as Meadowood
Interior Lighting		
Fixtures	mix of fluorescent, incandescent, and CFL	same as Meadowood
Average lighting load	0.9 watts per square foot	same as Meadowood
Control	toggle switches	same as Meadowood
Exterior Lighting		
Fixtures	Fourteen 150-watt high-pressure sodium area lamps; Ten 26-watt CFL perimeter lamps	Seventeen 250-watt high pressure sodium area lamps; Seven 150-watt incandescent flood lights; Three 26-watt CFL perimeter lamps
Estimated total exterior lighting load	3.0 kW	6.2 kW
Control	photocells	same as Meadowood
Domestic Hot Water		
Facility	One propane-fired boiler; provides water at 120^o F; rated at 399 kBtuh input with a 598 gal. per hour recovery at 60^o F temp. rise. One 534 gal. storage tank.	Five 100-gal. natural gas-fired boilers; provides water at 120^o F
Kitchen	One propane-fired boiler; (same as above).	One 100-gal. natural gas-fired boilers; water temp. set at 150^o F
Laundry	One propane-fired boiler; provides water at 160^o F; rated at 670 kBtuh input with a 603 gal. per hour recovery at 100^o F temp. rise. One 277 gal. storage tank.	One 50-gal. natural gas-fired boiler; water temp. set at 160^o F

Figure 1. Meadowood—Retrocommissioning Results

SAVINGS SUMMARY PROJECTION
Meadowood Nursing Center

EXISTING ENERGY USE

Building Area (Sq. Ft.)	Baseline Building	Existing Electric Energy (kWh/Yr)	Average Electric Demand (kW/Mo)	Existing Propane (Gallons Per Year)	Existing Annual Energy Cost	Existing EUI (BTU/Sq.Ft. per Year)	Existing ECI ($/Sq.Ft. per Year)
30,244	1999-2000 Total Energy Use	639,388	133	45,424	$103,072	209,580	$3.41

Note: Energy Use Index (EUI) and Energy Cost Index (ECI) are based on gross building square footage

OPERATION AND MAINTENANCE MEASURES

Recommendation Selection Owner	Recommendation Selection PECI	Finding Number	Energy Conservation Project Title	Electric Energy Saved (kWh/Yr)	Propane Saved (Gallons Per Year)	Annual Cost Savings	Implementation Cost	Simple Payback (Years)	% Reduction of Cost Savings
No	No	17	Install Programmable Thermostats*	1,136	215	$307	$0	0.0	0.3%
Yes	Yes	18	Adjust Vending Machine Operation	1,256	0	$110	$0	0.0	0.1%
No	No	14	Replace Twist Timers Controlling Heat Lamps*	2,383	(21)	$189	$134	0.7	0.2%
Yes	Yes	01	Enable Economizer Controls*	51,154	215	$4,679	$3,434	0.7	4.5%
Yes	Yes	03	Clean Return Air and Outside Air Filters	8,623	0	$828	$716	0.9	0.8%
No	Yes	12	Improve Walk-in Compressor Configuration	2,716	0	$260	$260	1.0	0.3%
Yes	Yes	04	Install Occupancy Sensors*	14,406	(128)	1,145	$1,684	1.5	1.1%
Yes	Yes	15	Tune-up Packaged HVAC Units	26,254	0	$2,521	$3,900	1.5	2.4%
Yes	Yes	10	Modify HVAC Supply and Exhaust to Minimize Building Negative Pressurization	6,510	423	$1,013	$3,250	3.2	1.0%
Total Recommendation Package as Selected by PECI				110,918	510	$10,556	$13,245	1.3	10.2%
15%	**Measure interaction of total package**			94,281	433	$8,973	$13,245	1.5	8.7%
Total Recommendation Package as Selected by Owner				108,203	510	$10,296	$12,985	1.3	10.0%
15%	**Measure interaction of total package**			91,972	433	$8,752	$12,985	1.5	8.5%

Note: Measures with an (*) in the title are mutually exclusive with other measures

CAPITAL IMPROVEMENT MEASURES

Recommendation Selection Owner	Recommendation Selection PECI	Finding Number	Energy Conservation Project Title	Electric Energy Saved (kWh/Yr)	Propane Saved (Gallons Per Year)	Annual Cost Savings	Implementation Cost	Simple Payback (Years)	% Reduction of Cost Savings
No	No	05	Install Automatic Flue Dampers	0	324	$298	$1,162	3.9	0.3%
No	No	09	Install Indirect Evaporative Cooling Module on Laundry HVAC Unit	4,775	0	$355	$3,444	9.7	0.3%
No	No	08	Install Indirect Evaporative Cooling Module on Kitchen HVAC Unit	7,317	0	$575	$6,027	10.5	0.6%
Total Recommendation Package as Selected by PECI				0	0	$0	$0	N/A	0.0%
15%	**Measure interaction of total package**			0	0	$0	$0	N/A	0.0%
Total Recommendation Package as Selected by Owner				0	0	$0	$0	N/A	0.0%
15%	**Measure interaction of total package**			0	0	$0	$0	N/A	0.0%

Note: Measures with an (*) in the title are mutually exclusive with other measures

TOTAL PROJECT SUMMARY (O&M and Capital Improvement Measures)

		Electric Energy Saved (kWh/Yr)	Propane Saved (Gallons Per Year)	Annual Cost Savings	Implementation Cost	Simple Payback (Years)	% Reduction of Cost Savings
Total Recommendation Package as Selected by PECI		110,918	510	$10,556	$13,245	1.3	10.2%
15%	**Weighted average measure interaction of total package**	94,281	433	$8,973	$13,245	1.5	8.7%
Total Recommendation Package as Selected by Owner		108,203	510	$10,296	$12,985	1.3	10.0%
15%	**Weighted average measure interaction of total package**	91,972	433	$8,752	$12,985	1.5	8.5%

Source: Portland Energy Conservation, Inc. 2001

As previously discussed, indoor air quality is an issue with intrinsic significance for LTC facilities. The energy savings associated with the exhaust fan is negligible as is the implementation cost. Annual savings associated with the air filters was estimated at $800 or 8,600 kWh/year. The cost of replacing filters on a regular basis was estimated at $700 annually.

Lighting controls. The engineers observed that several areas in the facility had extended periods of vacancy yet lights, controlled by toggle switches, remained on. We recommended installation of passive infrared wall switches in the administration office and employee lounge, and also ceiling-mounted ultrasonic occupancy sensors in the shower rooms. Implementation costs were estimated at $1,800, factoring in a $22 per sensor rebate from PG&E. Energy savings were estimated at $1,100/year and 14,400 kWh/year.

Re-Piping. In the laundry area of the facility, hot water (measured at 116^{o}F) was discovered coming out of the cold tap at the sink. Inspection of the piping arrangement showed that the piping layout was incorrect. This became a safety concern for facility staff and may have had energy savings if washers were using warm or hot water (the “cold” water line also served the clothes washers). Because this was primarily a safety concern, energy-cost savings were not calculated and further inspection was recommended.

Wagner Heights

HVAC units. Nineteen of the 20 packaged HVAC units were found to be near the end of their useful lives and would require increased maintenance costs if they continued to operate. While not recommended under the scope of this project, replacement was estimated to have a simple payback of 5.5 years, produce energy savings of 221,100 kWh/year, and improve indoor air quality and comfort. A second option was to tune-up these units (clean filters and coils, correct refrigerant charge, adjust air flow). This would save approximately $3,600 annually and produce energy savings of 28,100 kWh/year. The implementation cost was estimated at $5,900. The second option was recommended because of the limited financial ability of the facility and the operations and maintenance focus of the project.

Air leaks in AC units. Several of the rooftop HVAC units showed significant air leaks from the supply duct. An inspection of all systems and ductwork was recommended to remedy possible heating/cooling capacity problems, imbalanced air flow and unnecessary conditioning of supply air. The estimated savings associated with repairing the ductwork was $1,200 and 8,800 kWh/year. Implementation costs were approximately $2,100.

Lighting. During the night walk-through, engineers observed that lights remained on in ten different unoccupied spaces. Occupancy sensors for these areas were recommended at an implementation cost of $3,500, factoring in a $22 per sensor rebate from PG&E. Energy savings were estimated at 21,900 kWh/year and associated cost savings at $2,000 annually. It was also noted that approximately 15 percent of fluorescent fixtures in the facility contained T-12 lamps with magnetic ballasts. If replaced with 62-watt T-8 lamps and electronic ballasts, the resulting cost savings would be approximately $1,800 for an implementation cost of $6,000. The quality of light would also be improved by reducing the

Figure 2. Wagner Heights—Savings Summary Projection

Wagner Heights Nursing & Rehab Center

EXISTING ENERGY USE

Building Area (Sq. Ft.)	Baseline Building	Existing Electric Energy (kWh/Yr)	Average Electric Demand (kW/Mo)	Existing Nat. Gas (Therms Per Year)	Existing Annual Energy Cost	Existing EUI (BTU/S.F. per Year)	Existing ECI ($/Sq.Ft. per Year)
45,372	1999-2000 Total Energy Use	845,280	170	45,478	$112,866	163,818	$2.49

Note: Energy Use Index (EUI) and Energy Cost Index (ECI) are based on gross building square footage

OPERATION AND MAINTENANCE MEASURES

Recommendation Selection Owner	PECI	Finding Number	Energy Conservation Project Title	Electric Energy Saved (kWh/Yr)	Nat. Gas Saved (Therms Per Year)	Annual Cost Savings	Implem. Cost	Simple Payback (Years)	% Reduction of Cost Savings
Yes	Yes	07	Reduce Kitchen Domestic Hot Water Temperature	0	1,084	$769	$0	0.0	0.7%
Yes	Yes	23	Adjust Vending Machine Operation	1,256	0	$110	$0	0.0	0.1%
No	Yes	19	Calibrate and Adjust Thermostats	3,515	187	$468	$293	0.6	0.4%
No	Yes	04	Install Programmable Thermostat	2,551	262	$409	$289	0.7	0.4%
Yes	Yes	09	Repair Water Leak in Kitchen and Install Aerators	0	197	$140	$138	1.0	0.1%
Yes	Yes	21	Perform HVAC System Tune-up*	28,122	0	$3,559	$5,855	1.6	3.2%
Yes	Yes	17	Occupancy Sensor Lighting Control	21,892	(174)	$2,003	$3,476	1.7	1.8%
Yes	Yes	22	Tune Walk-in Refrigeration Equipment	3,498	0	$334	$586	1.8	0.3%
Yes	Yes	02	Repair Air Leakage at A/C Units*	8,788	468	$1,170	$2,100	1.8	1.0%
Yes	Yes	10	Repair Leaking Pressure Relief Valve*	0	38	$27	$50	1.8	0.0%
No	Yes	01	Balance Air System*	9,932	374	$1,213	$3,892	3.2	1.1%
Total Recommendation Package as Selected by PECI				79,555	2,437	$10,202	$16,678	1.6	9.0%
	15%	**Measure interaction of total package**		67,622	2,071	$8,672	$16,678	1.9	7.7%
Total Recommendation Package as Selected by Owner				63,557	1,613	$8,112	$12,204	1.5	7.2%
	15%	**Measure interaction of total package**		54,023	1,371	$6,895	$12,204	1.8	6.1%

Note: Measures with an (*) in the title are mutually exclusive with other measures

CAPITAL IMPROVEMENT MEASURES

Recommendation Selection Owner	PECI	Finding Number	Energy Conservation Project Title	Electric Energy Saved (kWh/Yr)	Nat. Gas Saved (Therms Per Year)	Annual Cost Savings	Implem. Cost	Simple Payback (Years)	% Reduction of Cost Savings
Yes	No	18	Install T8 Lamps and Electronic Ballasts	17,235	(137)	$1,785	$5,979	3.3	1.6%
No	No	05	Replace Flue Dampers on Hot Water Heaters*	0	306	$217	$1,070	4.9	0.2%
No	No	15	Replace Rooftop A/C Units*	221,123	1,498	$26,521	$145,912	5.5	23.5%
No	No	16	Replace Domestic Hot Water Heaters*	0	2,552	$2,419	$30,396	12.6	2.1%
Total Recommendation Package as Selected by PECI				0	0	$0	$0	N/A	0.0%
	15%	**Measure interaction of total package**		0	0	$0	$0	N/A	0.0%
Total Recommendation Package as Selected by Owner				17,235	(137)	$1,785	$5,979	3.3	1.6%
	15%	**Measure interaction of total package**		14,649	-116	$1,517	$5,979	3.9	1.3%

Note: Measures with an (*) in the title are mutually exclusive with other measures

TOTAL PROJECT SUMMARY (O&M and Capital Improvement Measures)

	Electric Energy Saved (kWh/Yr)	Nat. Gas Saved (Therms Per Year)	Annual Cost Savings	Implem. Cost	Simple Payback (Years)	% Reduction of Cost Savings
Total Recommendation Package as Selected by PECI	79,555	2,437	$10,202	$16,678	1.6	9.0%
15% Weighted average measure interaction of total pkg.	67,622	2,071	$8,672	$16,678	1.9	7.7%
Total Recommendation Package as Selected by Owner	80,792	1,476	$9,897	$18,183	1.8	8.8%
15% Weighted average measure interaction of total pkg.	68,672	1,255	$8,412	$18,183	2.2	7.5%

Source: Portland Energy Conservation, Inc. 2001 flicker associated with magnetic ballasts. Changing to T-8 lamps would provide an opportunity to improve the color and temperature of the lights. The estimated energy savings, of 17,200 kWh/year took into account the heating penalty and cooling benefit of the reduced lamp wattage. Cost savings also included reduced maintenance savings. This measure was not recommended at this time due to the high implementation cost.

Discussion

The outcome and success of the RCx process at these two sites have major implications for future programs pursuing energy-saving opportunities in long-term care facilities. The results are also interesting for their application beyond healthcare. The experiences of these facilities may provide insight into how the RCx process could be modified to make it a cost-effective strategy for other small to medium businesses to improve energy performance.

The RCx demonstration projects were successful at reducing energy use and improving the indoor environment of the two LTC facilities. Meadowood reduced its electricity use by 14 percent and Wagner Heights reduced its energy use by 8 percent through low cost O&M measures. In addition, both RCx studies included findings that had direct impact on indoor air quality and comfort.

As part of PG&E's program, the projects were cost-effective for the facility owners. The simple payback (implementation cost/energy savings) was 1.5 years for the Meadowood facility and 2.2 years for the Wagner Heights facility. However, these simple paybacks dramatically increase when the cost of the RCx study is included (Meadowood's becomes 4.3 years and Wagner Height's becomes 5.1 years).

The cost of RCx is based on 1) the complexity of the building systems, 2) the amount of equipment, and 3) the scope of the RCx process (Haasl & Sharp, 1999). It is less cost-effective for small to medium sized buildings, like most LTC facilities, for the reasons listed below:

- Small facilities have higher costs per square foot because the RCx process includes fixed costs that do not vary and tasks that must be performed regardless of building size.
- Small facilities usually have simpler HVAC systems that are less likely to have problems that can be corrected with a system tune-up.
- Small facilities often do not have experienced maintenance staff. Experienced staff can assist with the RCx process and increase its cost-effectiveness as well as improve the odds of persistence.
- Small facilities often do not have the surplus cash necessary to correct equipment deficiencies.

As demonstrated by this study, LTC facilities are likely to have small simple systems that are not in need of an elaborate analysis. Scaling-back on the scope of the RCx study, may be a successful strategy to capture energy savings and non-energy benefits within an acceptable payback period. For example, data logging represents a significant part of the cost of RCx a facility. At the two demonstration sites, a couple of findings were identified using data loggers, specifically, those related to equipment running during unoccupied periods. Data loggers were also used to verify additional measures. Weighing these benefits against the increased costs of the data logging, it may make sense for many small and medium sized buildings to reduce or eliminate the use of data loggers in RCx. Other avenues for reducing RCx costs include scaling down the RCx plan, performing less rigorous energy savings calculations and producing a shorter final report.

RCx is most often thought of as an energy efficient strategy best suited to large commercial buildings. At the same time, small and medium sized buildings are a sector with acknowledged difficulties in reducing energy use. Our findings suggest that RCx may have potential as an energy savings strategy in long-term care facilities as well as other medium sized buildings. It offers benefits beyond energy audits by identifying low cost energy savings measures and opportunities for non-energy improvements. However, additional study is needed to determine if RCx can be implemented cost effectively in this sector and to identify methods to increase its cost-effectiveness.

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