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ENERGY SAVINGS FROM OPERATION AND MAINTENANCE TRAINING FOR APARTMENT BOILER HEATING SYSTEMS

An Energy Study on Ten Low-Income Apartments

Energy Task Force of the Urban Consortium
Energy Efficient Facilities and Weatherization Unit

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PREFACE

1991 URBAN CONSORTIUM ENERGY TASK FORCE RESEARCH

THE URBAN CONSORTIUM (UC) is a special network of the Nation's largest cities and urban counties brought together by PTI to find new solutions to their common concerns. The UC provides a creative forum where elected and appointed officials can identify, test, and validate practical ways to improve the provision of public services while generating new revenue opportunities. With staff, management, and business services provided by PTI, the UC addresses the critical needs of large local governments through its three task forces: Energy, Environment, and Telecommunications and Information.

The Urban Consortium Energy Task (UCETF) has 20 members and was established to improve urban energy management and decision-making through applied research and technology transfer. The UCETF focuses on developing and sharing new approaches and innovative solutions to energy management problems with local governments. Projects are organized in thematic units and co-managed by a member of the Task Force.

A description of the 1991 program Units and projects are:

ALTERNATIVE VEHICLE FUELS AND TECHNOLOGIES (AVF)

Alternative vehicle fuels offer a very strong potential to aid in the reduction of U.S. dependence on foreign oil supplies, with the resulting benefits of decreased air pollution in urban areas. Local governments can play an instrumental role in realizing this potential through practical applied research and highly visible demonstrations of alternative fuels and technologies. Issues addressed this year include identifying (a) intensive and credible market development efforts based on an applied research and demonstration program that combines reliable technology with experience-tested applications, (b) environmental and energy diversity benefits, and (c) institutional and infrastructure barriers. The 1991 AVF unit consists of:

Broward County, FL -- *Dual-Fuel Conversion Demonstration and Technology Transfer Project*

New York City, NY -- *Alternative Fuel Vehicle: Financing Issues*

Denver, CO -- *Technical and Market Comparison Between H₂/CNG (Hythane), Electric Hybrid, and CNG Fueled Vehicles*

Denver, CO -- *An Alternative Fuels Fleet Evaluation System -- A Transfer Project*

Detroit, MI -- *Analysis of Institutional and International Limitations for Alternative Fuel Vehicles*

Washington, DC -- *Comparison of Energy Consumption, Energy Savings, and Environmental Effects of EV/PV vs. Conventional Gasoline Vehicle*

ELECTRICITY MANAGEMENT

Urban interests for electricity management focus on means to maintain stable, secure and reasonably priced supplies of electric energy. Approaches include procedures for better demand management, application of "least cost" planning concepts, appropriate use of decentralized and/or small power production facilities, improved end-use efficiency, and developing sound structures for cooperative action among municipalities and energy utilities. Urban strategies include support for decentralized "small" power production, along with better demand management and improved end-use energy efficiency. The successful development and implementation of such strategies will require close cooperation with the utility industry and will address topics in areas of institutional relations, source flexibility, and demand-side management. The 1991 Electricity Management Unit consists of:

Albuquerque, NM -- *Alternatives to Traditional Rate Setting*

Chicago, IL -- *Integrating Innovative Supply and Efficiency Techniques*

Chicago, IL -- *The Chicago Energy Management Cooperative*

Dade County, FL -- *Energy Cost Reduction Through Resource Recovery*

Detroit, MI -- Hydraulic Waste Energy Recovery (Phase II) City of Detroit Water Distribution System

San Jose, CA -- Utility/Local Government Partnership to Increase Energy Conservation in New Construction

ENERGY EFFICIENT FACILITIES

Activities involving energy efficient facilities are at present, part of a national effort to achieve maximum cost-effective energy productivity in the building sector. There exists a need for collaboration between local government officials responsible for energy and environmental programs and other local government officials responsible for facilities, as well as the Federal officials and private sector groups, e.g. utilities. New technologies and management/administration practices to advance energy efficiency in facilities require major partnership efforts and transfer programs. Multi-family housing that has a large concentration of low-income families presents a unique challenge to lowering energy costs and maintaining energy efficient facilities. Projects in this unit are:

Boston, MA -- Neighborhood Energy Efficiency Outreach Partnership

Columbus, OH -- Energy Efficiency and Indoor Air Quality: Solutions for Fire Stations

Louisville, KY -- Partnership Approach to Energy Efficiency in Non-Profit Facilities
Montgomery County, MD -- Technology Transfer of Building Energy Design Guidelines

New Orleans, LA -- Residential Utility Costs Comparative Study

Phoenix, AZ -- Variable Frequency Drive Applications Guide

Portland, OR -- Energy Savings Through Operation and Maintenance Training in the Low-Income Multi-Family Sector

Washington, DC -- Comparison of Two Techniques for Identifying Energy Conservation Measures in Low Income Homes

ENERGY, ENVIRONMENT and ECONOMIC DEVELOPMENT

This an area that has both visionary and immediate practical emphases on the definition and evaluation of realistic strategies and actions to support energy-sustainable and

environmentally responsible communities. Emphases include uses for renewable energy, practical domestic supply and conservation alternatives, and the synthesis of energy concerns with wider local government interests in economic development, environmental quality, and internal cost control. Urban strategies to improve energy-sustainability require attention to both broad based institutional changes, as well as specific projects designed to encourage the application of appropriate technology and community development practices. The "Sustainable Communities" project has involved three municipalities with State agency, Lawrence Berkeley National Laboratory, and a formal advisory committee with broad national representation. Projects under this unit are:

Austin, TX -- Energy Star Sustainable Rating Program

Phoenix, AZ -- Impact of Heat Island on Cooling and Environment: A Demonstration Project

Pima County, AZ -- Tucson Solar Village - Project Management

Portland, OR -- Sustainable City Transfer Project

San Francisco, CA -- Neighborhood Energy/Economic Development at South Bayshore

San Francisco, CA -- Sustainable City Transfer Project

San Jose, CA -- Sustainable City Transfer Project

Seattle, WA -- Coordination of Energy and Air Quality (CEAM)

Seattle, WA -- Bicycle Program -- Urban Trails System

Tucson, AZ -- Local Government Involvement in Long Term Resource Planning for Community Energy Services

Reports from each of these research projects, including this report, are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining any additional reports or further information about the Urban Consortium Energy Task Force and the Urban Consortium should contact:

Energy R&D Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004
1-800-852-4934

ACKNOWLEDGMENTS

The success of this Operation and Maintenance study is the result of contributions from many individuals. We wish to formally recognize them and their organizations, and express our appreciation for their assistance.

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Staff from Portland's Energy Office contributed in numerous ways, including Sue Ferland with clerical support, Marcy Wood having assembled the Operation and Maintenance Manual, and Director Susan Anderson for her leadership in the project's organization. Debbi Palermini, now of Palermini & Associates, helped write the original proposal and workplan.

Each property owner and especially the boiler operators of the ten participating buildings are due special recognition. We appreciate their enthusiasm and interest in energy efficiency and boiler safety, and particularly their efforts to follow through after the on-site training. They are the key to producing gains in fuel savings. We also extend our thanks to organizations and individuals who contributed resources used in the O&M Manual, including Oregon State University Energy Extension, the Minneapolis Center for Energy and the Environment, Oregon Department of Energy, New York State Energy Office, New York City Department of Housing Preservation and Development, Cleaver Books Co., International Telephone and Telegraph Co., Armstrong Co., Barnes and Jones Co., Contracting Business Magazine, Dwyer Instruments, Chemco, Lawrence Berkeley Labs, and authors Dan Holohan and James Blumbaugh.

David Tooze, Project Manager
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ENERGY SAVINGS FROM OPERATION AND MAINTENANCE TRAINING FOR APARTMENT BOILER HEATING SYSTEMS

City of Portland Energy Office

CHAPTER 1 - ABSTRACT

The Portland Energy Office provided operation and maintenance (O&M) training to the operators of boiler heating systems for ten low-income apartment complexes in the Fall of 1990. This study tracked energy usage before and after O&M training to see if savings occurred. Training was provided on both weatherized and non-weatherized apartments to find out if weatherization impacted the amount of O&M savings to be obtained. Also, energy savings from the O&M training and building shell weatherization are compared.

The O&M training averaged about four hours per building. Content was adjusted at each site to match needs of the boiler and operator. The Energy Office also provided a boiler tune-up by a service technician. The training stressed low-cost and no-cost measures which operators could either do themselves or hire service help to implement. It also emphasized boiler safety.

Nine of the ten apartment complexes in the study used less energy per heating degree-day after the O&M help. Average savings were 10%. Four apartments chosen randomly as controls had negative savings; they used slightly more energy during the same post-O&M time frame. Weatherized and unweatherized apartments showed similar savings after the O&M help, 10% and 11% percent respectively. Savings from weatherization of six of the apartments in the winter of 1988-89 were also measured. A low average of only 4 % was observed, reflecting negative savings in two buildings.

The results from this study point to respectable energy savings potential from improved boiler maintenance. Delivery of the O&M help cost about \$850 for an entire apartment building. This is much less costly than weatherization, which in Portland, has averaged \$850 per individual unit. The results are encouraging. However, they must be considered as case study findings. A larger study is needed to confirm the results and

extent of savings. The program design and purpose from this study are transferable to other jurisdictions who want to set up an O&M energy program.

CHAPTER 2 - INTRODUCTION AND PROJECT DESCRIPTION

OVERVIEW

Energy savings programs in low-income apartments usually stress building shell weatherization. Such projects in Portland have typically achieved 5-25% savings at an average cost of \$850 per unit. In many buildings, more efficient heat delivery from gas and oil boiler systems can provide further savings.

Usually, the person in charge of the boiler and related heat delivery system is the building manager or a maintenance person. They tend to have many other responsibilities. Their main concern with the heating system is to keep it running so the tenants are comfortable. They are often unaware of simple and inexpensive maintenance actions that can yield energy savings.

Although this study of ten apartment complexes is not large enough to be conclusive, it points to savings of about 10 percent from O&M actions. The study suggests that O&M training may be a more cost effective way to save energy than weatherization. If so, O&M actions should be done first, before more costly weatherization. (Delivery costs for this study averaged about \$850 per building or per boiler.)

The Portland Energy Office provided O&M training on heating system for building operators from each of the involved apartment buildings. Six of the apartment complexes received weatherization in the winter of 1988-89 through Portland's Multi-Family Weatherization Program (a joint City/utility program operating since 1987). The other four had applied to the program but had not weatherized to date. The Energy Office compared fuel oil or natural gas use before and after the O&M help to see if savings had occurred.

CROSS-SECTION OF PARTICIPANTS

Ten apartment complexes with twelve separate buildings and boilers were chosen for the study. Table 1 lists the apartment complexes and shows the breakout among different

factors. Key variables were whether a building was weatherized or not, and if it received O&M help. Half of the chosen sites had oil-fired boilers; half had gas-fired boilers.

The savings analysis divided the controls into the same before and after periods as those receiving O&M help, to provide comparisons.

Table 1
Categories of Participating Apartments

Apartment Name (# units)	Boiler fired by:	Heat Distrib. by:
<u>O&M Assistance, not weatherized</u>		
Lownsdale Hotel (43 units)	gas	steam
Babbette Manor (21 units)	gas	steam
Danmore Hotel (119 units)	gas	steam
Grand Oaks Hotel (42 units)	oil	steam
<u>O&M Assistance, weatherized</u>		
Hoyt St. Apartments (17 units)	gas (2 boilers)	hot water
Claremont Apartments (56 units)	gas (2 boilers)	hot water
Santa Barbara (22 units)	oil	steam
Kaye Manor (13 units)	oil	steam
Kings Hill (18 units)	oil	steam/hot water
Castle Rose (41 units)	oil	steam
<u>Controls</u>		
Knob Hill (36 units)	gas	
Glen Court (19 units)	gas	
Margot Apartments (19 units)	gas	
Alder St. Apartments (42 units)	gas	

SERVICES TO BUILDING OWNER

Initial contacts and arrangements were mostly made with building owners. The Energy Office provided them on-site training and tune-ups by a consulting engineer and a service technician. Each building operator (in most cases the on-site manager) received training. Each boiler received an efficiency test, and a tune-up when feasible. The building operator was helped to better understand how his system worked and what maintenance measures would save energy. Both efficiency and safety measures were stressed.

The training was tailored to the building and the interest and ability level of the operator. All operators were urged to take on simpler measures such as routine boiler blowdowns. Their responses to more complex or tedious tasks varied, as expected. For instance, some wanted to do their own tune-ups and tube cleaning. Others preferred help with how often to schedule service companies to do the work. Either method resulted in energy savings through improved maintenance.

SITE VISIT REPORT AND MANUAL

After the on-site visit and training, each owner and building operator received a site visit report with recommendations. The report reviewed factors about the particular installation and what was done during the site visit and training. The report also gave suggestions for further efficiency improvements with O&M actions. These recommendations included no-cost and low-cost operational changes the operator could do. In most cases they also urged further efforts which required hardware, parts, and/or service from a heating equipment technician. A sample of one of the write-ups is included as Appendix B.

The Energy Office also provided an Operation & Maintenance Manual to each participant. Each manual included a mix of information about a building's particular system and more generic tips and guidelines for the types of equipment involved. The manuals contained data about boiler operation, boiler types, burners and nozzles, troubleshooting, steam systems, hot water systems, booster pumps, thermostats and time clocks. They also included tips on hot water heaters and lighting efficiency factors. The table of contents and excerpts from one of the manuals are included as Appendix C.

TRANSFERABILITY

The program design and purpose from this study are transferable to other jurisdictions interested in developing O&M programs. The Portland Energy Office used a fairly straightforward process to find interested building owners, study the buildings, work with the operators, and check for savings. Several "lessons learned" also highlight problems to avoid in any future O&M training efforts. (See Chapter 5.)

The results from this study show energy savings potential from improved boiler maintenance. The reports and manuals published for each building should be a transferable framework for setting up training resources in other jurisdictions.

CHAPTER 3 - PROJECT DEVELOPMENT

Most of the setup work for the O&M study was done late Summer/early Fall 1991. With this schedule, the participants were committing themselves to a program to be imminently undertaken. Late Fall is the ideal time to do the training and look for O&M opportunities. Building owners and boiler operators tend to be more motivated, knowing that the heating season is just beginning. The boiler is working, so it can be shut off briefly for tests and adjustments. Also further service, if needed, is unlikely to cause a problem before cold weather has set in.

Table 2 reviews the timing of primary events and steps of the O&M study. Some of the items are discussed in more detail in the following paragraphs.

Table 2
Summary of Study Events and Timing

Event	Date	Comments
Select candidate buildings	Sept '90	Chose from among existing applicants to Energy Office Programs, per several criteria.
Gather billing histories	Sept '90-Nov '90	Some required several reminder calls.
Kickoff	Oct 25, '90	Two-hour meeting with lunch; both owners & operators invited.
Site visits	late Oct '90 -early Nov '90	All boilers were operational (heating season underway) by time of visit.
Site visit reports	by early Dec '90	Within one month of visit.
Follow-up phone calls	mid Dec '90 - early Jan '91	Contact owners about progress.
Post-O&M training meeting	Jan 15, '91	Compared notes, pictures, encouraged follow through with recommendations.
Further telephone follow-up	Feb '91	Check again with owners about progress.

Event	Date	Comment
Second on-site visit	Mar '91	A brief visit for questions, to see what had been done, and to encourage further action on measures not yet completed.
Gather post-O&M billing histories, data analysis	Summer '91	See Analysis of Results section.

IDENTIFYING & RECRUITING PARTICIPANTS

The Energy Office chose participants out of a pool of existing applicants to other Portland Energy Office Programs. Key criteria in selecting a building for the free O&M assistance were:

- Low income tenants.
- Consistent energy use records available (could not have partial fills of oil).
- Commitment to carry out recommended actions costing under \$500.
- Boilers at least ten years old.
- Mix of gas and oil fired boilers.
- Past weatherization work done (or not done, for comparison buildings).

HISTORICAL ENERGY USE DATA

The Energy Office obtained historical energy use data for all buildings in the study. Oil data was the hardest to get. One owner kept his own excellent delivery records, but the others' records had to be obtained from various vendors. Quite a few reminder calls were needed in some cases.

The gas company had to get most of the requested data from microfiche. Also, it changed its scheme of summarizing data in the midst of the requested period. Both layouts were hard to interpret. This made data entry tedious and often confusing.

KICK-OFF MEETING

This meeting was informative, short, and upbeat. It lasted two hours including a box lunch for participants. The Energy Office staff went over the program, and introduced the

engineer who would be visiting each building. The staff then asked operators to describe their buildings and surveyed them to assess their level of boiler knowledge and skills. The meeting also served as a good way to quickly schedule the O&M training visits for all buildings.

SITE VISIT, TUNE-UP, TRAINING

Site visits involving the consulting engineer and service technician ran from three to seven hours. Visits were very much tailored to the unique needs of each heating system and the skill level of each boiler operator. For example, as part of the O&M visit, the service technician checked for dirty burners and cleaned them if needed. One of the building operators wanted to do his own burner service. The technician provided him with a step-by-step training on how to disassemble and clean burners. Another operator chose the hands-off approach, but wanted specific information on when to schedule a contractor to service the boiler.

Although the depth of operator training varied based on a given operator's knowledge, interest, and responsibilities, the training followed this basic outline:

a) Basic principles	Show cross-sectional drawings of boiler, discuss how heat is transferred, remove panels to show cast iron sections, etc.
b) Boiler fittings	Reviewed safety valves, sight glass, bottom blowdown, pressuretrol, etc.
c) Feedwater accessories	Reviewed makeup and low-water cutoff valves, pressuretrol purpose and operation, need for blowdown.
d) Burner check, service	Checked efficiency, excess air, CO levels (gas), smoke number (oil), and stack temperature with operator participation. Cleaned and tuned (service tech) where possible.

e) Other controls	Observed operating cycles. Carefully went over existing controls locations, purpose, schedules. Discussed any control problems, adjusted setpoints, tracked down problems when possible.
f) Heat distribution	Made sure operator understood why any bottlenecks might occur, fixed immediately when possible.
g) DHW system	Watched circ pump operation cycles & actual delivered temperatures. Had operator make adjustments if appropriate.
h) Other	Reviewed other questions or operational problems for particular building/boiler and operator

The technician and engineer opened or serviced components whenever appropriate, to involve the operator in understanding and maintaining them. Safety concerns and practices were a constant theme during the training visits.

SITE VISIT REPORT

The site visit report was described previously. The reports were as concise as possible. Each report made specific recommendations, including cost estimates and likely savings for each O&M measure. They proved to be a great resource, especially for any building owner or other decision-maker who was not on site for the O&M visit. A sample report is included as Appendix B.

IMPLEMENTATION BY BUILDING OWNERS

The implementation of some measures could be done during the site visit. As much as possible, the engineer or service technician had the operator help with tests, adjustments, and servicing of equipment. Most of the building owners or operators completed any remaining low-cost measures shortly after the visit. One of the building owners paid for the service technician to come back and help him clean his very dirty atmospheric gas burner.

More expensive measures such as cleaning the cast iron plates, installing stack dampers, and adding new controls went uncompleted in most instances. One enthusiastic participant sold his building shortly after the study. In another case the non-profit building operator found out after the study that the building would be razed in a few years.

Even when more expensive measures were not done, the low cost measures appeared to save a substantial amount of energy.

O&M MANUAL

Each O&M manual reviewed the particular apartment's installation. It included data on the boiler, controls, pumps, float valves, air release valves, etc. It also gave helpful write-ups on different aspects of running and maintaining a boiler installation. Many excellent write-ups have been assembled by others, such as State of New York and City of Minneapolis. These existing materials were used wherever possible (with permission). See Appendix C for an example.

FOLLOW-UP ON IMPLEMENTATION

As noted, building owners responded well on the low-cost and no-cost actions. The Energy Office did several follow-up phone calls to check progress on other actions and to further encourage the owners. A brief follow-up visit was paid to several of the buildings. All of the participants appeared to remain enthusiastic about the O&M training.

POST-O&M ENERGY USE DATA

In general, the post-O&M data was easier to collect than the pre-O&M data since the gas company keeps the most recent twelve months in its active computer database. The oil data was also easier to obtain. Nonetheless, compiling energy data nearly always takes a few extra reminder phone calls.

ANALYSIS OF RESULTS - USE OF TRUE DAILY DEGREE-DAY VALUES

This study used a custom spreadsheet analysis approach to characterize energy savings. The spreadsheet contained daily Portland heating degree-day values for the entire study period. Most existing software programs (e.g., PRISM) use monthly degree-day totals.

The monthly totals for a given city and time period are easy to obtain and load in such a program. But there are disadvantages to using monthly instead of daily averages.

The monthly scheme figures pro-rated degree-days between two meter readings or delivery dates. This approach is simple and reasonable, but it does always compute a "wrong" value for degree-days. Its estimated value matches true degree-days only when the data period exactly fills a calendar month. An example of the discrepancy for a monthly gas bill is as follows:

Assuming a billing period between 12/10/90 and 1/10/91:

The actual tally of daily degree-days = 1025

The pro-Rated Value from monthly degree-days = 890

(Total Dec 90 deg-days = 933, and total Jan 91 deg-days = 802)

The monthly pro-rate approach under-estimates by 13%.

In this example the monthly pro-rate approach had no way to anticipate a cold spell during late December to early January. The error for oil can be even more exaggerated. Depending on oil tank size, some of the buildings in this study needed several oil deliveries within the above cold period. As a result, some of the monthly pro-rated degree-days are more than 20% too low.

Obviously the pro-rate approach would weaken any correlation of energy used versus degree-days. The daily data is harder to track down and load. But it helps give more meaningful correlations for each oil delivery or gas meter reading. This was especially important for the fairly short pre- and post- periods in this study.

The analysis approach in this study was fairly simple. Total therms of gas or gallons of oil were divided by the degree-days for each pre- and post- period (heating season only). An initial attempt was made to subtract out the baseline energy use using various methods. However, the short periods of pre- and post- data for this small study gave inconsistent results. This was especially true where baseline savings occurred. The use per degree-day ratios were more consistent with the baseline usage left in. Also, some buildings which did have enough data to subtract out the baseline use showed similar savings with it left in. Though it is less theoretically precise, leaving in the baseline use

was reasonable for this study. Electrical usage was omitted, and the baseline portion of gas or oil was only about 15% of the cold weather use for most buildings. In all, the approach was simple and yielded straightforward results. Copies of the spreadsheets are included as Appendix D.

Table 3 shows the calculated savings using the approach described above. For this small sampling, no data was thrown out. The average results show trends, but with the small sample in this study they are not conclusive. Savings after O&M efforts occurred on all but one of the twelve boiler heating systems (ten apartment complexes). The following section reviews the savings more closely.

Table 3
Summary of Savings for Study Participants & Controls

APARTMENT NAME	Fuel	HEATING ENERGY SAVINGS						HIGHLIGHTS OF O&M ACTIONS
		Use Factor, Therms or Gals./DDay						
		For Weatherization		For O&M		% Savings	% Savings	
Pre-	Post-	% Savings	Pre-	Post-	% Savings			
WEATHERIZED								
Hoyt St. Bldg B (4509)	gas	1.44	1.33	8%	1.33	1.20	10%	Fixed control problems, cleaned burners.
Hoyt St. Bldg A (4411)	gas	0.81	0.79	12%	0.79	0.77	3%	(Same for both Hoyt St. buildings.)
Claremont Bldg A (SE 42nd)	gas	4.03	4.47	-11%	4.47	3.96	11%	Adjusted controls, began blowdown program.
Claremont Bldg B (SE Morrison)	gas	3.20	3.50	-9%	3.50	3.26	7%	(Same for both buildings at Claremont.)
Santa Barbara	oil	2.38	2.10	12%	2.10	1.79	15%	Cleaned very dirty burner.
Kaye Manor	oil	1.28	1.21	5%	1.29	0.97	25%	Cleaned very dirty burner (smoke no. was 5).
Kings Hill	oil	1.89	1.60	15%	2.14	2.21	-3%	Excellent routine maintenance, no changes.
Castle Rose	oil	2.60	2.50	4%	2.50	2.19	12%	Extreme soot deposits removed prior to visit.
Average of Weatherized median				4% 7%			10% 11%	
UNWEATHERIZED								
Lownsdale Hotel	gas				4.93	4.01	19%	Replace air vents, burner tuneup.
Babette Manor	gas				3.27	2.91	11%	Blowdown badly needed, thermostat moved.
Danmore Hotel	gas				10.41	9.74	6%	Control adjustments, incr. blowdown frequency.
Grand Oaks	oil				4.02	3.30	18%	Repaired/replaced/re-sized air vents.
Average of Unweatherized median							11% 14%	
CONTROLS (All unweatherized)								
CONTROL - Knob Hill	gas				4.67	5.44	-16%	Controls were chosen at random from buildings
CONTROL - Glen Court	gas				3.18	3.23	-2%	that received energy audits from Portland
CONTROL - Margot	gas				2.64	2.31	13%	Energy Office programs, but did not opt to
CONTROL - Alder St.	gas				5.26	5.99	-14%	weatherize or get O&M training.
Average of Controls median							-2% -8%	

Notes: 1. Medians are shown to help offset effect of extremes. 2. Refer to Appendix D for details about analyses of energy savings.

CHAPTER 4 - RESULTS

ENERGY SAVINGS

The O&M Study made three comparisons of energy savings:

1. Apartments that received O&M training and an energy-oriented tune-up, compared to those that did not. The pre- and post- energy use per degree-day ratios from Table 3 compare as follows:

	<u>Average Savings</u>
Those that received O&M (12 boilers)	10%
Those that did not receive O&M (4 controls)	-2%

On average, the buildings/boilers participating in the O&M study appear to have saved energy while those not participating used slightly more energy. Eleven of the twelve boilers receiving O&M help showed savings (see Table 3). Note that the boiler showing no savings was very well maintained already, and few O&M recommendations could be made.

2. Weatherized apartments that received O&M training and an energy-oriented tune-up, compared to unweatherized apartments receiving the same O&M measures.

	<u>Average Savings</u>
Weatherized, that received O&M	10%
Unweatherized, that received O&M	11%

The weatherized buildings included measures such as attic and floor insulation, storm window treatment, and minor caulking and weatherstrip. As shown in Table 3, eight of the twelve buildings/boilers in the study (six of ten apartment complexes) were pre-weatherized. For the small sampling in this study, weatherized versus non-weatherized buildings made no obvious difference in the opportunity for O&M savings.

3. Savings from weatherization, compared to savings from O&M training and an energy-oriented tune-up on the same buildings. (See Table 3.) All of the O&M training and

tune-ups were done in late October and early November in 1990. All of the previous weatherization work was done between June 1988 and February 1989.

	<u>Average Savings</u>	
Results from weatherization	4%	(7% median)
Results from O&M	10%	(11% median)

For the small sampling in this study, savings after the O&M efforts were at least as much as the savings from earlier weatherization work. The median results are also given to help show that magnitude of savings was similar for weatherization and O&M. One of the weatherized apartment complexes showed a 10% increase in energy use (the Claremont, with two buildings/boilers). This brought the average down. The other five weatherized complexes (six buildings/boilers) averaged 9% savings.

The data also allows informal comparisons between gas and oil. Savings were comparable. Gas savings averaged 10%, oil averaged 13%.

IMPORTANT NOTE ABOUT RESULTS: The results and averages of a study such as this one are very useful to show trends. Overall study results suggest significant savings from O&M efforts, no notable difference in O&M opportunity for weatherized vs. non-weatherized buildings, and comparable savings for weatherization and O&M measures in the same buildings. But because of the very small sample studied, it is not valid to conclude that similar savings would be obtained on a large scale. Further evaluation of large samples of apartment boiler heating systems are needed to confirm the trends indicated in this study.

O&M ACTIONS WITH SAVINGS POTENTIAL

Table 4 reviews the types of O&M actions that were done or recommended for the twelve buildings/boilers involved in this study. Typical industry savings claims for each O&M action are given for reference. Table 4 also shows how often each type of action was recommended among the twelve buildings and their heating systems.

Table 4
Typical O&M Recommendations and Savings Potential

O&M Action	Description	Typ cost of measure	Typ. claimed savings/yr*	# of relevant bldgs in study**
Tune-up	Adjust gas air/fuel ratio; clean oil burner	Approx \$80-\$240; costs more for oil	2-15%; highest is for very dirty oil burner	8
Clean tubes	Brush off soot buildups on boiler tubes or plates	Service call (free by oper.)	1-4%	7
Blowdowns	Initiate a routine for this safety & effic. measure	\$0; simple task	eventual loss in eff if not done	8
Smaller oil nozzle	Over-firing causes 1% eff loss per 35° extra out stack	\$20 extra w/ tune/clean	1-6%	3
Outside air reset (n/a for steam)	Adjust existing or add this basic control	\$0 or \$175 if new, + labor	3-4% or more	4
Other control adjustment	Drop steam pressure or hot water circ temp, etc	\$0-varies per control type	1-5% or more; varies w/ type	5
Check traps (steam systems)	check for plugged or leaky traps	\$25-50 ea if replaced+labor	2-5% or more	4
Air vents (steam systems)	Repair or replace if plugged	\$5-20 ea if replaced+labor	2-5% or more, plus better heat distribution	4
DHW tune-up	Adjust gas air/fuel ratio; clean oil burner	Approx \$40-\$120; costs more for oil	1-2%	4
DHW settings	reduce circ. frequency or temperature	\$0 if done by operator	1-2% or more	9
Other measures	Fix an installation error, replace faulty pump, etc.	\$0-varies per measure	varies per measure	11

* Estimated savings are as a percent of total gas or oil used at the apartment (electricity is excluded).

Note that a DHW savings of 1% overall reflects about 4-7% savings on the water heater itself.

** Number of relevant buildings, of the 12 buildings/boilers in the study (10 total apt. complexes).

EFFECTIVENESS OF ON-SITE TRAINING

The building operators (and interested owners) took pre- and post- tests about their knowledge of boiler systems. The "tests" were given quite informally and were aimed at finding out what they wanted to learn, as well as what they did not know. Almost all of the operators felt they poorly understood the boiler before the O&M visit. All of them said they understood their boiler much better afterwards.

For example, about half of them did somewhat regular blowdowns before the O&M training, and only one operator felt he really understood how the related float/low water cutoff valve worked. The others rarely or never did blowdowns, which are a vital aspect of boiler safety and efficiency. After the O&M training all of the operators felt they understood the blowdown valve and intended to do regular blowdowns. Most of the operators felt they could now make control adjustments with more confidence. They expected to achieve both comfort and energy benefits.

BENEFITS OTHER THAN ENERGY SAVINGS

Weatherization projects often have side-benefits of improved comfort or aesthetics. O&M measures often yield such bonuses as well. Steam systems in particular can get "locked up" with air if an operator does not understand the air release valves or if the valves are faulty. The heat then "just never seems to get to" tenants farthest away from the boiler. These problems existed to varying degrees on three of the buildings, one quite serious. The O&M actions in these cases made an immediate difference. Such a measure saves energy by making the boiler run more efficiently. But the ability to provide heat to areas that were cold before can partly offset the savings.

COST PER APARTMENT COMPLEX

The average costs per building for the engineer and service technician are given in Table 5.

Table 5
Average Costs for O&M Help in Portland Study

Item	Cost/Apt.	Explanation
O&M Visit	\$465	Included \$225 O&M training by engineer + \$240 tune-up w/ service technician
Report/ Recommendations	\$230	Included calculations & phone calls to vendors for cost estimates
O&M Manual	\$95	Included time to collect generic data for boiler plate, plus specifics for each apartment complex
Follow-up Visit	\$60	Answered any questions, encouraged further action where not completed
Total	\$850	

CHAPTER 5 - LESSONS LEARNED

Table 6 gives a summary of "what worked well" and "areas of difficulty" in the tasks of the

Table 6 "Lessons Learned" from Portland's Apartment O&M Study		
Item	What Worked Well	Areas of Difficulty
Billing Data		Hard to get; especially oil data. Gas records hard to read.
Initial Call	Free tune-up & customized training were attractive offer.	
Selecting Buildings		Hard to find low income bldgs with old boilers in Ptld, due to many replacements when district steam shut down in early 80's.
		Hard to find complete oil use history.
Service Contractor	Now an increased energy efficiency slant for this company.	Most companies are geared toward safety and avoiding smoke, but not toward getting another 10% efficiency from boiler/system.
Scheduling	Pre-meeting with all participants together was very helpful.	
	Early in heating season may be best, when boiler is running but can be shut down for adjustments without big inconvenience.	
Commitment from Building Owners	Both owners and operators seemed motivated about low-cost O&M items.	More expensive recommendations such as cleaning of boiler cast iron plate surfaces (after heating season) often did not get done.
Effectiveness of O&M Training	Operators were surprisingly interested and picked up basics quickly.	Operators are accountable for tenant comfort but not energy bills, may be hard to stay motivated.

Item	What Worked Well	Areas of Difficulty
	Most had been at job several years, so should carry forward effect of training for some time.	
Also Push Electric Energy Measures		This intended aspect of study got largely ignored due to lack of opportunity; most electric use is controlled by tenants who pay bills.
Used Daily Degree-Days for Savings Analysis	In past studies, the pro-rated monthly degree-days give poor usage/d-day correlations (PRISM), especially for an oil delivery which might only last a few days during a cold snap.	Set up a spreadsheet approach to tally true degree-day amounts from daily values. Harder to set up but much clearer correlation for every single month of data.

O&M study. A consistent positive theme was the enthusiasm of the operators. They were able to quickly learn boiler and heating system principles they had not previously understood. On the other hand, one of the most tedious parts of the study was pulling together the energy use data, which required a lot of reminder phone calls.

CHAPTER 6 - CONCLUSIONS; SUGGESTED FUTURE RESEARCH

Although this study used too small a sampling to be conclusive, it does point to the following conclusions:

1. The objective to reduce energy use with O&M training appears to have been met for nine of the ten apartments that participated in this study.
2. If these results are shown to be valid on a larger scale, they show that any oil or natural gas program aimed at saving energy should invest in O&M first, as the cost of O&M training roughly equals the cost of weatherizing one single apartment unit!

Suggestions for future research:

1. A wider study of energy savings after apartment O&M training would strengthen the conclusions of this small preliminary study, and more accurately quantify savings.
2. Present these results to Oregon Department of Energy's State Home Oil Weatherization (SHOW) Program, and its advisory committee. The SHOW program presently provides weatherization help but it does not now fund any O&M help.
3. Likewise, present these findings to Northwest Natural Gas Company. Their energy audit and weatherization incentives include neither heating system efficiency nor O&M measures at present.
4. A business opportunity may exist for HVAC service contractors. For example, offering service that is "more than just a tune-up", and saves energy and money besides.
5. A study may be warranted to find out if similar savings can be obtained for single family boilers and oil-fired furnaces. Also gas forced air furnaces.
6. Look for other possible matches with utilities to pursue a larger project in Portland.

APPENDICES

APPENDIX A - SAMPLE FORMS, MEMOS, OTHER DOCUMENTS

APPENDIX B - SITE VISIT REPORT SAMPLE

APPENDIX C - O&M MANUAL TABLE OF CONTENTS

APPENDIX D - ENERGY ANALYSIS SPREADSHEETS

APPENDIX A

SAMPLE FORMS, MEMOS, OTHER DOCUMENTS

APARTMENT BOILER OPERATION AND MAINTENANCE TRAINING

**PRESENTED BY THE CITY OF PORTLAND
ENERGY OFFICE**

We welcome you as a participant in our Boiler Operation and Maintenance (O&M) Training project. Our objective is to produce energy savings in apartment boilers by providing O&M training to managers or staff responsible for operating the heating system.

You are invited to attend an informal orientation meeting where we will explain the project, what the Energy Office will do for you, and how you will be involved in the project. We will introduce Energy Office staff and the project's consulting engineer, and answer questions you may have.

Here is the basic information about the meeting.

WHEN?	THURSDAY, OCTOBER 25th, 12:00 noon to 1:30 pm.
WHERE?	FULTON PARK COMMUNITY CENTER.
DIRECTIONS:	SEE THE ENCLOSED MAP FOR DIRECTIONS TO 68 SW MILES STREET.
WHAT ELSE?	A BOX LUNCH WILL BE PROVIDED.
QUESTIONS?	Call David Tooze, City of Portland Energy Office at 796-7582.

Thank you for your willingness to participate and learn. See you next Thursday!

David Tooze
Project Manager
City of Portland Energy Office

CITY OF

PORTLAND, OREGON

ENERGY OFFICE

Mike Lindberg, Commissioner
Susan Anderson, Director
Room 1030, The Portland Building
1120 S.W. Fifth Avenue
Portland, Oregon 97204
(503) 796-7222
FAX (503) 796-3388

AGENDA

PORTLAND ENERGY OFFICE
OPERATION AND MAINTENANCE TRAINING PROJECT

OCTOBER 25, 1990

- I. WELCOME AND INTRODUCTIONS
- II. PROJECT PURPOSE
- III. SCOPE OF WORK AND TIMELINE
- IV. LUNCH
- V. PARTICIPANT SURVEY
- VI. OVERVIEW OF TRAINING/WALK-THRU
EXAMPLES OF OPERATION AND MAINTENANCE
MEASURES

PORTLAND ENERGY OFFICE

OPERATION AND MAINTENANCE PROJECT

ENERGY OFFICE: WHAT WE DO

1. Review operation and maintenance needs.
2. Provide walk-thru training.
3. Do boiler tune-up and other O&M.
4. Provide O&M guide and checklists.
5. Evaluate energy savings.

PROPERTY MANAGERS: WHAT YOU DO

1. Go on walk-thru training with Greg and Dave.
2. Do additional necessary O&M.
3. Keep up with O&M throughout project.
4. Provide access to energy use records.

OWNERS: WHAT YOU DO

1. Pay for capital improvements, if identified, up to \$500 (Above \$500, improvements are optional.)

WHO TO CALL:

Dave Tooze, Energy Office	796-7582
Sue Anderson, Energy Office	796-7418
Greg Marsh, Engineer	1-581-5934

City of Portland Energy Office
Boiler O&M Assistance - Survey of Interest Areas

Date: _____

Name: _____ Phone: _____

Apt. Bldg. Name & Address: _____

O&M Items:	Understand?		interest area?	do self	get serv.
	yes	no			
Boiler water inventory					
why makeup water?					
why chemicals? deposits, oxygen					
why blowdown?					
low water cutoff to protect boiler					
pressure relief (safety) valve					
pressure reducing valve (PRV)					
Burner					
is it natural or forced draft?					
why is draft needed?					
what is boiler efficiency?					
how to measure efficiency					
visual symptoms of poor flame					
Circulation system					
how does air get in?					
why purge air? how?					
steam system -					
how does condensed steam return?					
function of check valve on return					
diagnosing failed traps					
hot water system -					
expansion tank					
circulation pump - replace seal?					
On/off controls					
steam system -					
pressuretrol					
hot water system					
aquastat					
Routine maintenance					
Review manual - copy available?	Yes ___	No ___	Not sure ___		
Frequency of service calls	Yearly ___	As needed ___			
Lubrication (some pumps & blowers)					
Check pump seals					
Check pressuretrol or aquastat					
Check safety relief					
Clean out soot - flue brush					
Clean burner					
Check efficiency, draft					
Routine checks -					
Visual burner check					
Watch for leaks					
Other checks per manual					

COMMENTS

CITY OF PORTLAND ENERGY OFFICE
APARTMENT BOILER O&M DATA

Sheet 1

APARTMENT NAME		DATE:	BY:
ADDRESS			
CONTACT NAME, PHONE			

BUILDING DATA

year built	
no. floors, units/floor	
tot. no. of units	
total sq.ft.	

BOILER DATA

boiler description:	
steam or hydronic?	
gas or wt. oil?	
cast iron sect./other?	
boiler changes & dates	
boiler nameplate data	
burner nameplate data, nozzle size	
circ. pumps location(s), data	
other	

Boiler fittings

	data/location/settings:	comments:
aquastat (deadband?)		
pressuretrol(s)		
water glass		
feedwater regulator		
low water cutoff		
safety relief valve		
steam pressure limit		
temperature gage(s)		
pressure gage(s)		
air vent(s), auto/man.		
blowdown valve(s)		
other items, notes		

(Attach further notes & sketches where applicable)

APARTMENT NAME:		DATE:	BY:
-----------------	--	-------	-----

HEATING SYSTEM DESCRIPTION

description of zone control & heat delivery system(s)	
Describe pipe insulation	

DOMESTIC HOT WATER SYSTEM

description, nameplate data, setpoint and actual temperature; show schematic if side arm DHW	
Describe pipe insulation	

CITY OF PORTLAND ENERGY OFFICE
APARTMENT BOILER O&M DATA

Sheet 3

APARTMENT NAME:	DATE: BY:
-----------------	-----------

O&M CHECKS, ADJUSTMENTS/CLEANING

	before adjustment:	after adjustment:	notes:
Flue gas	°F stack	°F stack	
	°F room	°F room	
	°F net	°F net	
	%CO2	%CO2	
	%O2	%O2	
	%CO (gas)	%CO	[should be less than 5ppm]
	smoke # (oil)	smoke #	[should be no. 2 or less]
	" draft	" draft	
	%efficiency	%efficiency	
Burner for oil:	visual flame		
	burner dirty?	cleaned?	
	nozzle size, condition?		
	electrode dirty?		
Aquastat (hydronic)	°F setpoint	°F setpoint	
	°F deadband	°F deadband	
Pressuretrol (steam)	psig setpoint	psig setpoint	
	psig actual	psig actual	
Low water cutoff	OK?		
Pressure cutoff (steam)	OK?		
Other safety; items & condition			
Soot accumulation	thickness?	cleaned?	

**CITY OF PORTLAND ENERGY OFFICE
APARTMENT BOILER O&M DATA**

Sheet 4

[illegible]

Heating Season Start Date: _____ Heating Season End Date: _____

Date	Mo./Day
Outdoor Temperature	* F
Tot. Hours of Runtime	Hrs. Time-clock is "On"
Stack Temperature	* F
Boiler Pressure	Setpoint Actual Reading Setpoint
Boiler Water Temperature	Actual Reading
Blowdown:	Boiler Blowdown
3-Dry	Low-water
2-Moderate	Cutoff Blow
1-Clean	During Low-Water Blow
Other Data:	

[illegible]

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CITY OF
PORTLAND, OREGON
ENERGY OFFICE

Mike Lindberg, Commissioner
Susan Anderson, Director
Room 1030, The Portland Building
1120 S.W. Fifth Avenue
Portland, Oregon 97204
(503) 796-7222
FAX (503) 796-3388

January 8, 1991

To: Owners and Boiler Operators
participating in the Portland Energy Office
Operation and Maintenance Training Study

Luncheon Meeting Announcement

When? Tuesday, January 15, 1991 - 12:00 noon to 2:00 pm

Where? City Hall, Room 154 - 1220 SW 5th, Portland (for parking, check the parking garage in the Portland Bldg, 1 block north, enter from 4th St.)

What? A Box Lunch Meeting for property owners and staff.

Purpose?

1. Boiler operators will be asked to highlight 2 or 3 new practices learned as a result of the site visit and walk through.
2. Review what changes you have done as result of the site visit. Come prepared to tell the group what you have already done, and what you intend to do in the future.
3. The Energy Office will present operators with the Operation and Maintenance manuals.

Reminders

- The target date for completing the recommendations from the Site Visit Report (pg. 3, 4, and 5) is January 30. In order to measure energy savings, we need 3 to 4 months of heating data after you implement the site visit report recommendations.
- Keep record of what improvement/ work is done to the heating system. Note the date, and send us a copy of the work order if you hire a service contractor to assist you.
- If your fuel is oil, continue to completely fill the tank with each delivery, and note the number of gallons delivered. Dip measure the tank when the boiler improvements are completed.

Questions? Call David Tooze, Portland's Energy Office, 796-7582.

AGENDA

PORTLAND ENERGY OFFICE OPERATION AND MAINTENANCE TRAINING PROJECT FOR APARTMENTS, JANUARY 15, 1991

- I. Welcome and Introductions
- II. Review the program.
 - The program purpose
 - What has happened so far.
 - What has yet to be done.
- III. Short survey of what recommendations and energy upgrades have been completed on your boiler/ heating system.
- IV. Roundtable discussion about Greg and Keith's visit to your building.
 1. Greg will briefly introduce your building. then maintenance staff will tell about 2 or 3 energy saving or maintenance opportunities found as a result of the visit.
 2. Maintenance staff will describe what recommendations from the site visit report have already been done to the building.
 3. Maintenance staff or owner will describe what work they intend to complete by January 30.
- V. LUNCH
- VI. Program Survey
- VII. O & M Manuals
 - introduction of content
 - how to use the boiler room log.
- VIII. What is next?
 - Keep records of all work done (invoices, dates etc)
 - Energy Office will follow-up by phone
 - If using oil, continue completely filling tanks, recording the gallons used. Dip measure the tank when energy measures are completed.

**WHAT SITE VISIT RECOMMENDATIONS HAVE YOU INMPLEMENTED
AS OF TODAY? (1-15-91)**

Your Name: _____
Apartment: _____

Boiler

Burner

Circulation System

On/Off Controls

Routine Maintenance

Other

Certificate of Participation

This Certifies That

Bill Noland

Merits grateful recognition as a participant in

O&M Training for Apartment Boilers

And is hereby awarded this certificate
by

City of Portland Energy Office

Organization

Portland, Oregon

City and State

on this Fifteenth day of January 19 91

David Toole

Mike Lindberg

APPENDIX B

SITE VISIT REPORT SAMPLE

THE SANTA BARBARA APARTMENTS

Operation & Maintenance
Training for Apartment
Boiler Heating Systems

Site Visit Report
and Recommendations

provided by:

City of Portland Energy Office

Susan Anderson, Project Director

David Tooze, Project Manager

funded through:

Energy Task Force
of the Urban Consortium

Year Twelve, 1990

Prepared by Marsh Technical Services

November 30, 1990

THE SANTA BARBARA APARTMENTS

OPERATION & MAINTENANCE TRAINING FOR APARTMENT BOILER HEATING SYSTEMS

SITE VISIT REPORT AND RECOMMENDATIONS

Background

The City of Portland Energy Office is providing on-site operation and maintenance (O&M) training to boiler operators at thirteen apartment buildings. The project will investigate if closer attention to equipment maintenance and system tuning yields energy savings in these buildings. Both weatherized and non-weatherized buildings will be evaluated.

Boiler safety and tenant comfort are a boiler operator's highest priorities. However, most apartment buildings can save energy by closer attention to boiler O&M. The background, skills, and focus areas of those who operate apartment boilers vary greatly. The boilers and related heating systems also differ greatly in age, type, and condition. A successful O&M program must be compatible with the actual system and the person who runs it.

Although the optimal O&M measures will vary per building, energy savings can be obtained in three basic ways:

1. Make the boiler fire more efficiently. (Clean/refurbish burner, change nozzle size, adjust air/fuel ratio, more frequent blowdowns, adjust draft, clean tubes, etc.)
2. Cycle the boiler more efficiently. (Vary operating times & temperatures with outside temperature, minimize short-cycling, add automatic stack damper, use separate domestic hot water heater in summer, etc.)
3. Maintenance to steam or hot water distribution system. (Refurbish pumps, replace or repair clogged traps & air vents, check all local controls, etc.)

This project tailored each O&M training visit to the particular building and boiler operator. Some boiler operators are already well-versed in routine O&M actions such as blowdown, burner adjustments, tube cleaning, and trap repairs. Others preferred to start from scratch. In all cases, the training staff and the boiler operator discussed where fine-tuning or control changes might help cut energy costs.

This report reviews O&M findings for the boiler, steam distribution system, and domestic hot water heater at the Santa Barbara Apartments. It also gives specific O&M recommendations for the Santa Barbara. An O&M manual and additional site visit will follow.

Site Visit Details

The City of Portland Energy Office provided O&M training and a review of present operation at the Santa Barbara Apartments on October 30, 1990. The Following persons were present:

For Santa Barbara Apartments (2052 SE Hawthorne, Portland 97214):
Chris Zupsic, owner, 2712 SE Salmon, Portland 97214, 233-1010
George Warn, Maintenance/boiler operator, 233-1010

For City of Portland:
Dave Tooze, Energy Analyst, Portland Energy Office 796-7582
Greg Marsh, project consulting engineer, Marsh Technical Services 581-5934
Keith Weiss, project service technician, Tri-M Mechanical 244-1111

Dave Tooze arranged the site visit. Greg Marsh worked with George Warn to understand the system, and review any problems and potential control changes. Keith Weiss went through basic safety checks with George, and performed routine service where appropriate. The site O&M training effort was informal, a combined effort to exchange as much information as possible. Emphasis was on the operator taking readings, servicing equipment, or making adjustments himself wherever feasible. Greg Marsh prepared this report.

Findings

1. Building Description. Built 1932, brick 3-floor plus basement, 22 total units. The City of Portland Energy Office earlier provided an energy audit and partial funding for ceiling and floor insulation, weatherstripping, pipe insulation, and storm windows.
2. Present Energy Use. The Santa Barbara boiler uses about 11,000 gallons of oil per year. The domestic hot water loop probably consumes at least 25% of the total. At present rates oil cost is about \$14,000 per year.
3. Boiler Description. Cast iron sectional, steam, Weil-McClain BL 686-S-W, installed 1977.
4. Burner Description. Peabody Gordon-Piatt RL8-0-0.5. Rated at 10.2 GPH of no. 2 oil.
5. High Smoke Number. The Bacharach smoke number (where a certain quantity of air is drawn across a white filter to see how much soot is deposited) was 4 or a bit higher when the boiler was first tested. A #2 smoke number is ideal; 0 or 1 may mean that too much excess air is being fed to the burner, and 3 is the highest acceptable level without expecting a lot of soot deposit on the heat transfer surface of the boiler's cast iron sections.
6. Burner Service, Improved Smoke Number. Pulled burner to inspect and clean. Replaced nozzle. The smoke number was now 2.

7. 77 % Efficiency, High Stack Temperature. 12.2% CO₂; 4.5% O₂; and 800° flue - 70° room = 730° F net stack temperature on day of visit. Per combustion efficiency table, this gives 77% efficiency and 25% excess air. The combustion itself could not be much more efficient. But the high stack temperature leaves room for improvement. See recommendations.
8. Soot Deposits. One inspection plate was removed on the cast iron sections. There is a heavy soot layer on the cast iron surface. It acts as an insulator, so a lot of the heat that could go to making steam instead goes out the flue.
9. Blowdown/Safety Checks.
 - Water makeup/low-water cutoff valve: Blowdown of this float valve successfully caused boiler to shut off.
 - High pressure cutoff: When temporarily adjusted to a lower pressure setting, this controller successfully caused the boiler to shut off. Its normal setting is 10 psig.
 - Blowdown: A lot of "mud" came out when the boiler blowdown valve was opened.
10. Other Boiler Fittings.
 - Pressure gage: It reflects pressure changes, but the readings seem low. Because of piping arrangement the gage could not be removed easily to check for partial plugging.
 - Pressuretrol: Honeywell control. The boiler was set to cycle on at 3 psig, and off at 4 psig (setting of 3 psig and 1 psig deadband). Changed to: on at 1 psig and off at 3 psig; should give somewhat less cycling.
 - Low temperature control: Honeywell controller set to cycle boiler on if water drops below 180°, for domestic hot water heating loop.
11. Boiler Control. Time clock is adjusted seasonally to meet the building's heating needs. In the summer the boiler cycles to keep minimum temperature for domestic hot water loop.
12. Steam Piping. Notes:
 - Two-pipe system with condensate return tank and pump.
 - Insulation. The exposed steam, condensate, and hot water piping in the basement is not insulated.
 - Radiator valves and traps appeared good in the room that was checked. The packing nuts were tightened during the visit because they were loose enough that the valves were a bit sloppy. The valve handles were fairly rusty, suggesting that a regular steam leak has existed at some time.
 - Air vent valve at the condensate return tank worked fine. (It needs to quickly vent any air in the system and then re-seal each time the boiler comes on.)
13. Domestic Hot Water (DHW).
 - The boiler includes a "side-arm" heat exchanger within the hot water portion of the boiler. The boiler must run year-round for the DHW heating. In the summer it does not make steam.
 - The Bell & Gosset circulation pump bearing is bad enough that it overheats and freezes up the shaft, then cools off and runs some more. George will repair it or get it serviced.

- The blend of circulated water bypassing and going through the side-arm heater is now set manually. The temperature jumped around some during the morning visit. An old Watts automatic mixing valve had been removed.

14. Very Able Boiler Operator. George Warn is new at apartment building maintenance and boilers, but from his industrial experience he was able to quickly pick up everything covered during the operation and maintenance visit. He asked a lot of questions and tagged several equipment items with notes about their purpose or settings. He very actively worked with Keith Weiss on servicing the burner, and felt he would be comfortable doing most regular maintenance items in the future.

Recommendations

1. Brush out soot to improve efficiency. 77% efficiency is fairly good, but at least 2% improvement should be easily obtained by brushing off the soot buildup in the cast iron boiler sections. Each percentage improvement will save nearly \$150/year. The best conceivable efficiency is about 84%. Brushing out the soot buildup will reduce the very high stack temperature by putting more of the heat into steam production. Most boiler service companies will provide this service. Or George may want to do it.

POSSIBLE SAVINGS: 2-6% of total oil usage

2. Smaller burner nozzle. A smaller nozzle might work in the oil burner. With the energy conservation changes made to date, and better boiler performance from cleaning the fire side of the boiler, smaller nozzles may be sufficient (see Attachment A). The slower firing would cause less frequent cycling. It would also allow a larger portion of the heat to be transferred. A lower stack temperature would result. Each 35° F drop raises efficiency about 1%. Any change in nozzle size should be made at a future service date, but only if George feels that the boiler still cycles some on very cold days.

POSSIBLE SAVINGS: 1% of total oil usage

3. Insulate exposed steam & DHW pipes. Although the steam and condensate pipes run hotter than the DWH pipes, they are hot for only part of the year, and for fewer hours per day. Nonetheless, insulation is a good investment. Jacketed fiberglass is likely to cost \$3 to \$6 per foot, depending on pipe size and accessibility. Estimated payback is as follows:

Steam piping, POSSIBLE SAVINGS: Will pay for itself in about 6 years. Actual dollar savings depends on length of pipe, not measured.

DHW piping, POSSIBLE SAVINGS: Will pay for itself in about 4 years. Actual dollar savings depends on length of pipe, not measured.

4. Domestic hot water (DHW) adjustments. Controls for boiler low water temperature and DHW temperature could likely be dropped 10° with no ill effects. Setpoints could then be inched downward still further, if tenants do not experience any hot water shortage. The manual valve bypass adjustment works surprisingly well for

holding the circulation temperature. But it could be held much tighter by installing a tempering valve.

POSSIBLE SAVINGS: About 2-3% of total oil usage. The temperature adjustments would cost nothing. The approximate \$100 cost of the tempering valve should pay for itself quickly.

Note that an independent DHW heater would be more efficient for summer operation. Having to fire the boiler and incur all of its standby losses probably requires twice as much fuel during those months as would a stand-alone system.

5. Motorized flue damper. A strong draft continues through the boiler after the burner shuts off. The air is drawn from the boiler room and passes through all of the sections that were designed to transfer heat. A lot of heat from the boiler is thus lost out the flue. A motorized damper can be installed which will seal off the draft whenever the burner is not running. For example, a damper sold by Energy Vent achieves a 98% seal. One local vendor says it runs about \$1000 installed, for a 16" flue pipe. See Attachment B

POSSIBLE SAVINGS: At least 5-10% of total oil usage. At present oil costs a motorized flue damper should pay for itself within two years or sooner. Damper manufacturers claim that even 25-35% savings are common.

6. Other measures that may be a good idea but will not save energy directly.
 - Remove and check pressure gage and its piping at a convenient time when other service is being done.
 - Service DHW circulation pump, as noted in Findings.
 - Blow down the boiler and float valve routinely, e.g. weekly, during the heating season. (George was going to hook up a hose from the blowdown over to the drain.)
 - Any or all of the following gages & testing equipment would be helpful:
 - Stack thermometer, for performance monitoring - approx \$40
 - Smoke test pump, to alert need for burner service or more combustion air - \$40 for Dwyer or \$60 for Bacharach model.
 - Combustion test kit, to check efficiency and get feedback on any changes. Dwyer sells a complete kit for \$210 (through Grainger), including stack thermometer and smoke tester. (See Attachment C.) The more deluxe Bacharach kit is much more expensive.
 - Chemical treatment with a "pot feeder" will arrest oxygen corrosion which occurs in all boiler and piping systems. (See Attachment D.) Relatively cheap protection.

O&M Manual

An O&M manual will be provided for each apartment building in this project. It will be a loose-leaf notebook with O&M data, suggested regular O&M actions, a weekly/monthly data record sheet, and a place to store service records and equipment data. It will include suggestions for getting copies of missing O&M Instructions from vendors.

MULTI-FAMILY ENERGY CONSERVATION

DATA SHEET No.

26

Page 1 of 1

REDUCING OIL FIRING RATE by
REDUCING NOZZLE SIZE

Past practice in sizing furnaces, including the oil burners, was to provide excess heating capacity of 25 to 50%, sometimes 100% or more. The reason given was to provide quick, "pick-up"; whereas, often, the ability of the furnace supplier to figure heat loss of the house was a "guess". With relatively low past fuel costs, the often resulting low efficiencies were not noted.

In addition, in buildings which have had insulation added in ceilings, walls, and roof, storm windows and doors added, and existing doors with windows weather-stripped, plus caulking cracks in exterior walls; energy losses were reduced and demand for fuel heat has also been reduced, further decreasing boiler or furnace efficiency.

Reduced nozzle size requires less fuel and air, which provides for more "on" time of the burner and more uniform heating. The smaller oil burner nozzle with reduced fuel and air delivery, also reduced temperature of fuel gases going up the chimney, further reduces heat loss.

Combustion efficiency tests are a "must" for the new nozzle as well as smoke scale tests. In all cases, recommendations of the oil burner manufacturer must be followed, including complete "tune-up" of the existing system. The ideal size of nozzle and oil delivery, would be a 100% on time, for the burner and furnaces, during a 15°F day, with apartment temperature maintained at 68°F.

Many newer oil burners can be fitted with smaller delivery nozzles; however, some older models provide difficulty in so doing.

Source: Cornell University Cooperative
Extension, Energy Facts #32.

APARTMENT HOUSE INSTITUTE, NYC TECHNICAL COLLEGE

Under contract to NYS Energy Office. This data sheet was prepared with the support of the U.S. Department of Energy, Grant #80-CS-69114. However, any opinions, fundings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

Santa Barbara Apartments

Attachment B

AUTOMATIC FURNACE VENT DAMPERS

For use with direct spark ignition (DSI), intermittent or cycle pilot and standing pilot systems that have dual automatic valve combination gas controls. Motorized vent damper increases efficiency of gas furnaces by reducing standby heat losses from the furnace, as well as loss of heated room air. When combustion is required, damper rotates to open position, and burner is activated. If damper does not rotate to open position, burner circuit will not be activated. When the burner is off, the damper closes, trapping residual heat in furnace, for distribution throughout your home. Closing time: 20 sec nominal.

In case of power failure, damper blade

opens automatically. If damper blade should become immobilized in the open position, heating plant will continue to operate in the normal manner, controlled by the room thermostat and furnace high limit control. Aluminum damper casting and damper actuator assembly. 24V, 60 Hz. Thermostat heat anticipator setting: 0.2A. Power consumption: motor 5W. Mounts directly above (on chimney side of draft diverter. Prewired with plug to fit Honeywell and Penn Johnson spark systems. Remove plug and wire to terminals if using with standing pilot or other spark systems. AGA Certified. Do not use for oil-fired, power burner, or direct vent applications. Honeywell brand.

Fits These Dayton Furnaces	Honeywell Model	Stock No.	List	Each	Shpg Wt
4" 3E279 3E283	D80D1009	2E742	\$287.80	\$133.90	5.1
5" 3E252 3E253 3E280 3E281	D80D1017	2E743	272.90	136.45	5.3
6" 3E284 3E286 3E287 3E288	D80D1025	2E744	282.80	141.40	6.7
3E254 3E282 3E285					

8" size also available

Energy Vent makes a similar product in larger sizes, which achieves a 98% seal.

Dwyer®

No. 1200 Combustion Test Kit

Makes all 4 tests: 1. CO₂ Content 2. Stack Temperature 3. Draft 4. Smoke

Quickly tests oil, gas and coal-fired installations — residential, commercial and industrial

This new Dwyer Kit provides everything you need to make a complete combustion efficiency test — simply and quickly. Accuracy to 1% CO₂ fully meets the requirements of the professional heating engineer. Yet an apprentice can follow the simple step-by-step instructions.

After checking and adjusting the installation for a clean burning fire, you will have approximately 8% to 12% CO₂ — and stack temperature will be about 500° to 600° F. Transfer these figures to the Dwyer Slide Rule Calculator, and read off the percentage combustion efficiency instantly.

This quality kit has everything — plus extra supplies.

No. 1200-A Test Kit includes: (1) New easy-to-carry, impact resistant, custom-molded polyethylene Carrying Case. All components are nested for quick access and protection from damage. (2) No. 1101 CO₂ Indicator — Clear acrylic plastic, virtually unbreakable. 4" adjustable scale, 0 to 16% in .2 divisions. Finger-tight inlet valves — no tools needed to renew absorbent solution. O-ring seals will not leak. (3) Aspirator Bulb, Filter and Tubing Assembly — Has refillable filter, metal terminal tube and CO₂ indicator valve adapter. (4) Filter Wool — Extra supply in bag. (5) No. 171 Draft Gage — Continuously indicating, permanently accurate. Durablock® precision plastic construction; built in spirit level. 0 to .25" W.C. range in .01 divisions. Models 170 and 172 (optional, not shown) have 0 to .5" and 0 to 1.0" ranges respectively. Magnehelic® equipped. (See optional Model 1200-B at rt.). (6) New Dwyer Smoke Gage Pump — Fast-working; the first known unit to conform with ASTM D-2156-XX standards for testing smoke density in flue gases from burning distillate fuels. (7) Smoke Filter Paper — A new, exclusive Dwyer development. Roll of filter paper is contained in a dispenser box for protection and quick use. (8) See Model 1200-B at rt. (9) Awl — Pierces smoke pipe for thermometer and sampling tubes. (10) CO₂ Absorbent Solu-

tion — Extra supply for many tests. (11) No. A-503 Stack Thermometer — Dial type, stainless steel; 200° to 1000° F range in 10° divisions. 2 1/4" dial, 5" stem. (12) Gage Oil — Long-lasting extra supply. (13) Spring Holders — For thermometer and metal terminal tubes. (14) Hole Plugs — Packet to fill awl holes. (15) Smoke Chart — Laminated plastic, for comparison with samples taken. (16) Dwyer Combustion Efficiency Slide Rule — Simple to operate. Back side demonstrates the relationships of flame height, temperature, smoke sample, gage readings. Laminated plastic; wipes clean. (17) Operating Instructions — Simple, illustrated. Shows step-by-step use of each item. Plastic. (18) Combustion Data Cards and Parts List — Plastic. Weight complete only 6 lbs. 8 oz.

No. 1200-B Test Kit. Includes portable Dwyer 2000-00-AV Magnehelic® Gage with large 4" dial instead of No. 171 Inclined Draft Gage. 0 to .25" W.C. range in .005" divisions and 300-2000 FPM velocity. Accurate within 4% of full scale. No leveling necessary; no gage oil needed. Kit is otherwise identical to No. 1200-A. Wt. only 7 lbs. 5 oz. *Optional* Magnehelic® 2000-0-AV, range 0-.50 W.C., or Model 2001-AV from 0-1.0" W.C.

Dwyer No. 920 Smoke Gage Kit only — Let you determine the relative amount of smoke resulting from combustion. New Smoke Gage Pump, tubing, metal terminal tube and tube holder, sampling paper smoke chart, hole plugs, durable case and complete instructions.

Dwyer No. 1101 CO₂ Indicator Kit. Range 0-16% CO₂. Includes carrying case, aspirator bulb with tubing and filter, terminal tube with holder, hole plugs, awl extra filter wool and absorbent solution efficiency slide chart and instructions.

No. 800-5 and No. 800-60 Carbon Dioxide Indicators

Used for testing atmospheres on board ships and submarines, in greenhouses and in inert gas and CO₂ blanketed flammable liquid tanks and compartments. These two Dwyer models offer a choice of ranges and provide a quick, easy indication of the percent of carbon dioxide. Direct reading is taken from the position of fluid level on the calibrated scale.

The instrument bodies are precision machined from a virtually unbreakable solid block of clear acrylic plastic, on chrome-plated steel base. One charge of absorbent solution will serve for over 500 tests. Unit comes complete with tubing, aspirator bulb, metal carrying case and instructions.

Left — No. 800-5 CO₂ Indicator, range 0-5% CO₂

Right — No. 800-60 CO₂ Indicator, range 0-60% CO₂

DWYER INSTRUMENTS, INC.

P.O. Box 373, Michigan City, Indiana 46360, Phone: 219-879-8000 Fax: 219-872-9057 Telex: 25916

• Anaheim CA 714 630 6424
• Houston TX 713 446 1146

• Marietta GA 404 427-9406
• Ivyland PA 215 957-0355

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LITHO IN USA 39

Santa Barbara Apts.
Attachment D

CHEMICAL TREATMENT FOR SMALL BOILERS
WITH MINIMAL MAKEUP WATER

BYPASS (OR "POT") FEEDER

PER CHEMCO, 1 GAL. UNIT COSTS ABOUT \$160,
PLUS INSTALLATION. USUALLY ADD NITRITE
FORMULA SUCH AS CHEMCO # 4364. 15 GALS.
OF CHEMICAL MAY LAST SEVERAL SEASONS

Santa Barbara Apts.
Attachment D, cont.

TYPICAL NITRITE FORMULA:

Chemco
WATER TECHNOLOGY INC.

4364

CLOSED SYSTEM TREATMENT

Application

A liquid corrosion inhibitor for use in closed loop heating and cooling systems. Corrosion protection is accomplished by the formation of a mono-molecular film on all metal surfaces in the system. The product contains buffers to control system pH, a thermally stable (572°F) copper inhibitor and synthetic polymer to disperse metal oxides and lubricate pump seals.

Dosage

Normal dosage is 5 to 10 gallons per 1,000 gallons of water. The inhibitors used are of a permanent nature and are lost only when water is lost from the system.

Feeding

If the system is tight, a bypass feeder is adequate. If frequent losses are anticipated, a chemical metering pump should be installed.

Packaging

Available in 510, 280, 140 or 46 pound steel drums.

Technical Data

Form	Liquid
Color	Yellow
Density, #/gallon	9.45
pH of 1% solution	9.4

Safety Data

Practically non-toxic but as with all chemicals, protective clothing and goggles should be worn when handling. **STRONG OXIDIZER.**

1/20/90

PROFESSIONAL WATER TREATMENT SERVICES

6014 N.E. 124th Court, Vancouver, WA 98682 (206) 892-2418 FAX (206) 892-3518

APPENDIX C

O&M MANUAL TABLE OF CONTENTS

OPERATION & MAINTENANCE MANUAL

Operation & Maintenance Training for Apartment Boiler Heating Systems

provided by:

City of Portland Energy Office

Susan Anderson, Project Director

David Tooze, Project Manager

funded through:

Energy Task Force
of the Urban Consortium

Year Twelve, 1990

Prepared by Marsh Technical Services and Portland Energy Office Staff

January, 1991

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APPENDIX D

ENERGY ANALYSIS SPREADSHEETS

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
<i>note: only the "winter" D-Days are included in averages</i>								
Kings Hill Apts.			Summary:		pre-Wx	1.89		
11/6/90					post-Wx	1.60	15%	
					pre-O&M	2.14		
					post-O&M	2.21	-3%	
Pre- and post-weatherization data:								
10/15/87	1047				<i>Use factor before weatherization:</i>			
11/12/87	685	305	2.25	2.25	24.5			
11/28/87	616	302	2.04	2.04	38.5			
12/15/87	823	388	2.12	2.12	48.4			
12/24/87	498	295	1.69	1.69	55.3			
1/5/88	853	359	2.38	2.38	71.1			
1/19/88	696	509	1.37	1.37	49.7			
2/2/88	704	527	1.34	1.34	50.3			
2/20/88	801	403	1.99	1.99	44.5			
3/9/88	544	338	1.61	1.61	30.2			
4/5/88	907	470	1.93	1.93	33.6			
5/3/88	769	369	2.08	2.08	27.5	1.89	pre-weatherization	
9/20/88	378	446	0.85		2.7			
11/8/88	387	354	1.09		7.9			
11/29/88	780	408	1.91	1.91	37.1			
12/14/88	426	331	1.29	1.29	28.4			
12/30/88	652	421	1.55	1.55	40.8			
1/13/89	521	326	1.60	1.60	37.2			
1/31/89	648	441	1.47	1.47	36.0			
2/5/89	433	249	1.74	1.74	86.6			
2/11/89	348	228	1.53	1.53	58.0			
3/13/89	514	697	0.74		17.1			
3/30/89	542	320	1.69	1.69	31.9			
5/30/89	235	519	0.45		3.9	1.60	post-weatherization	
Pre- and post-O&M data:								
11/12/89	889	635	1.40		5.4			
11/28/89	669	310	2.16	2.16	41.8			
12/16/89	826	421	1.96	1.96	45.9			
1/11/90	1298	626	2.07	2.07	49.9			
1/25/90	734	354	2.07	2.07	52.4			
2/2/90	424	199	2.13	2.13	53.0			
2/13/90	616	281	2.19	2.19	56.0			
2/22/90	518	277	1.87	1.87	57.6			
3/10/90	637	293	2.17	2.17	39.8			
3/24/90	559	240	2.33	2.33	39.9			
4/21/90	618	276	2.24	2.24	22.1			
5/22/90	785	331	2.37	2.37	25.3	2.14	pre-O&M	
9/13/90	526	163	3.23		4.6			
11/24/90	1498	714	2.10	2.10	20.8			
12/20/90	1540	626	2.46	2.46	59.2			
12/27/90	812	328	2.48	2.48	116.0			
1/2/91	530	242	2.19	2.19	88.3			
1/7/91	391	193	2.03	2.03	78.2			
1/16/91	452	218	2.07	2.07	50.2			
1/27/91	505	301	1.68	1.68	45.9			
2/9/91	674	289	2.33	2.33	51.8			
2/27/91	652	300	2.17	2.17	36.2			
3/13/91	739	292	2.53	2.53	52.8			
4/10/91	1215	499	2.43	2.43	43.4			
4/30/91	534	278	1.92	1.92	26.7			
6/28/91	1200	471	2.55		20.3	2.21	post-O&M	

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
note: only the "winter" D-Days are included in averages								
Castle Rose			Summary:		pre-Wx	2.60		
10/16/90					post-Wx	2.50	4%	
					pre-O&M	2.50		
					post-O&M	2.23	11%	
6/19/87	228							
7/3/87	171	24	7.13		12.2			
7/17/87	168	51	3.29		12.0			
7/31/87	175	38	4.61		12.5			
8/18/87	220	3	73.33		12.2			
9/4/87	202	0	#DIV/0!		11.9			
9/17/87	188	32	5.88		14.5			
10/20/87	409	124	3.30		12.4			
11/3/87	406	158	2.57	2.57	29.0			
11/11/87	311	105	2.96	2.96	38.9			
11/23/87	552	204	2.71	2.71	46.0			
12/3/87	567	221	2.57	2.57	56.7			
12/16/87	781	313	2.50	2.50	60.1			
12/23/87	534	233	2.29	2.29	76.3			
12/29/87	485	219	2.21	2.21	80.8			
1/5/88	573	201	2.85	2.85	81.9			
1/21/88	435	581	0.75	0.75	27.2			
1/24/88	689	143	4.82	4.82	229.7			
1/28/88	439	173	2.54	2.54	109.8			
2/5/88	542	296	1.83	1.83	67.8			
2/12/88	389	152	2.56	2.56	55.6			
2/19/88	400	164	2.44	2.44	57.1			
2/27/88	456	166	2.75	2.75	57.0			
3/9/88	442	203	2.18	2.18	40.2			
3/23/88	613	252	2.43	2.43	43.8			
4/5/88	644	235	2.74	2.74	49.5			
4/15/88	350	131	2.67	2.67	35.0			
4/26/88	392	148	2.65	2.65	35.6			
5/11/88	540	185	2.92	2.92	36.0			
6/1/88	462	153	3.02	3.02	22.0			
6/21/88	396	88	4.50		19.8			
7/20/88	348	53	6.57		12.0			
8/16/88	282	12	23.50		10.4			
9/13/88	313	14	22.36		11.2			
9/29/88	206	81	2.54		12.9			
10/14/88	505	42	12.02		33.7			
11/11/88	989	318	3.11	3.11	35.3			
11/21/88	462	193	2.39	2.39	46.2			
12/5/88	793	325	2.44	2.44	56.6			
12/20/88	798	333	2.40		53.2	2.60	pre-weatherization	
1/2/89	768	340	2.26	2.26	59.1			
1/17/89	822	343	2.40	2.40	54.8			
2/1/89	798	391	2.04	2.04	53.2			
2/10/89	867	386	2.25	2.25	96.3			
2/27/89	954	430	2.22	2.22	56.1			
3/13/89	764	322	2.37	2.37	54.6			
3/28/89	694	282	2.46	2.46	46.3			
4/13/89	595	197	3.02	3.02	37.2			
5/1/89	456	146	3.12	3.12	25.3			
5/19/89	370	107	3.46	3.46	20.6			
6/12/89	476	142	3.35		19.8			
7/7/89	360	76	4.74		14.4			
8/10/89	391	30	13.03		11.5			

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
note: only the "winter" D-Days are included in averages								
9/8/89	307	26	11.81		10.6			
10/5/89	377	72	5.24		14.0			
10/25/89	510	170	3.00	3.00	25.5			
11/7/89	474	213	2.23	2.23	36.5			
11/21/89	528	215	2.46	2.46	37.7			
12/12/89	953	440	2.17	2.17	45.4			
12/22/89	584	317	1.84	1.84	58.4			
1/6/90	826	368	2.24	2.24	55.1			
1/17/90	535	229	2.34	2.34	48.6			
1/31/90	791	368	2.15	2.15	56.5			
2/13/90	790	329	2.40	2.40	60.8			
2/23/90	609	298	2.04	2.04	60.9			
3/5/90	391	173	2.26	2.26	39.1			
3/13/90	405	193	2.10	2.10	50.6			
3/26/90	486	194	2.51	2.51	37.4			
4/13/90	509	198	2.57	2.57	28.3			
4/26/90	372	127	2.93	2.93	28.6			
5/18/90	680	235	2.89	2.89	30.9			
6/4/90	485	120	4.04		28.5			
6/18/90	333	66	5.05		23.8			
7/3/90	203	7	29.00		13.5			
7/18/90	173	1	173.00		11.5			
8/8/90	233	3	77.67		11.1			
8/22/90	146	0	#DIV/0!		10.4			
9/13/90	261	9	29.00		11.9			
10/4/90	268	27	9.93		12.8			
10/25/90	664	258	2.57	2.57	31.6			post-weatherization
11/12/90	629	237	2.65	2.65	34.9	2.50		pre-O&M
11/27/90	663	281	2.36	2.36	44.2			
12/11/90	704	315	2.23	2.23	50.3			
12/22/90	683	379	1.80	1.80	62.1			
12/31/90	735	390	1.88	1.88	81.7			
1/9/91	596	306	1.95	1.95	66.2			
1/23/91	678	333	2.04	2.04	48.4			
2/5/91	719	326	2.21	2.21	55.3			
2/18/91	524	233	2.25	2.25	40.3			
3/6/91	650	292	2.23	2.23	40.6			
3/22/91	762	334	2.28	2.28	47.6			
4/8/91	652	289	2.26	2.26	38.4			
4/22/91	479	198	2.42	2.42	34.2			
5/7/91	461	182	2.53	2.53	30.7			
5/24/91	534	195	2.74	2.74	31.4			
6/14/91	501	160	3.13		23.9			
7/2/91	370	83	4.46		20.6			
7/26/91	257	4	64.25		10.7			
8/23/91	300	2	150.00		10.7	2.23		post-O&M

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
note: only the "winter" D-Days are included in averages								
Grand Oaks					pre	4.02		
11/6/90					w/Wx	3.30	18%	
12/28/88	1565							
1/4/89	1596	166	9.61		228.0			
1/16/89	1061	296	3.58	3.58	88.4			
1/23/89	1000	176	5.68	5.68	142.9			
2/1/89	1049	261	4.02	4.02	116.6			
2/7/89	1251	297	4.21	4.21	208.5			
2/14/89	1000	228	4.39	4.39	142.9			
2/28/89	975	340	2.87	2.87	69.6			
3/10/89	972	253	3.84	3.84	97.2			
3/27/89	1980	303	6.53	6.53	116.5			
4/12/89	972	210	4.63	4.63	60.8			
10/13/89	1264	621	2.04		6.9			
11/8/89	1462	351	4.17	4.17	56.2			
12/1/89	1090	410	2.66	2.66	47.4			
12/13/89	1420	266	5.34	5.34	118.3			
12/29/89	1374	469	2.93	2.93	85.9			
1/19/90	1653	451	3.67	3.67	78.7			
2/2/90	1459	352	4.14	4.14	104.2			
2/15/90	972	350	2.78	2.78	74.8			
2/26/90	1249	275	4.54	4.54	113.5			
3/15/90	1070	330	3.24	3.24	62.9			
4/26/90	1449	455	3.18	3.18	34.5			
6/10/90	1000	378	2.65		22.2			
11/9/90	1485	530	2.80		9.8	4.02	pre-O&M	
11/16/90	593	106	5.59		84.7			
11/26/90	793	199	3.98	3.98	79.3			
12/12/90	1409	367	3.84	3.84	88.1			
12/18/90	567	172	3.30	3.30	94.5			
12/30/90	1802	523	3.45	3.45	150.2			
1/13/91	1477	430	3.43	3.43	105.5			
1/28/91	1452	372	3.90	3.90	96.8			
2/13/91	1359	325	4.18	4.18	84.9			
3/1/91	710	267	2.66	2.66	44.4			
4/3/91	1641	614	2.67	2.67	49.7			
4/22/91	794	275	2.89	2.89	41.8			
5/8/91	385	197	1.95	1.95	24.1			
6/13/91	480	329	1.46		13.3	3.30	post-O&M	

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
note: only the "winter" D-Days are included in averages								
Kaye Manor			Summary:		pre-Wx	1.28		
11/2/90					post-Wx	1.21	6%	
					pre-O&M	1.29		
					post-O&M	0.97	25%	
5/28/87	627							
8/25/87	656	181	3.62		7.4			
11/9/87	723	373	1.94	1.94	9.5			
12/23/87	1030	926	1.11	1.11	23.4			
1/26/88	1144	1123	1.02	1.02	33.6			
3/2/88	909	826	1.10	1.10	25.3			
4/14/88	860	714	1.20	1.20	20.0			
6/16/88	754	567	1.33	1.33	12.0			
10/13/88	765	199	3.84		6.4	1.28	pre-weatherization	
12/5/88	1070	810	1.32	1.32	20.2			
1/5/89	769	705	1.09	1.09	24.8			
2/13/89	1183	1094	1.08	1.08	30.3			
3/27/89	1100	889	1.24	1.24	26.2			
5/8/89	525	367	1.43	1.43	12.5	1.21	post-weatherization	
9/8/89	820	347	2.36		6.7			
11/6/89	648	429	1.51	1.51	11.0			
12/18/89	897	828	1.08	1.08	21.4			
1/25/90	918	902	1.02	1.02	24.2			
3/6/90	1060	895	1.18	1.18	26.5			
5/3/90	1053	719	1.46	1.46	18.2			
8/2/90	450	328	1.37		4.9			
12/11/90	1603	1081	1.48	1.48	12.2	1.29	Pre-O&M	
1/7/91	877	938	0.93	0.93	32.5			
2/28/91	990	1057	0.94	0.94	19.0			
5/3/91	1074	1032	1.04	1.04	16.8			
7/31/91	762	462	1.65		8.6	0.97	Post-O&M	

Apartment O&M Savings Analysis- OIL

Date	gals	D-Days	gals per D-day	winter gal/DD	gals used per day	AVG gals per D-day	% savings	
note: only the "winter" D-Days are included in averages								
Santa Barbara								
10/30/90			Summary:		pre-Wx	2.38		
					post-Wx	2.10	12%	
					pre-O&M	2.10		
					post-O&M	1.79	15%	
8/20/87	692							
10/6/87	1012	56	18.07		21.5			
11/13/87	1137	359	3.17	3.17	29.9			
12/13/87	1615	601	2.69	2.69	53.8			
12/29/87	1028	509	2.02	2.02	64.3			
1/19/88	1353	689	1.96	1.96	64.4			
2/6/88	1072	631	1.70	1.70	59.6			
3/6/88	1345	544	2.47	2.47	46.4			
4/5/88	1200	530	2.26	2.26	40.0			
5/11/88	1252	445	2.81	2.81	34.8			
7/12/88	1034	282	3.67		16.7			
9/22/88	964	83	11.61		13.4			
11/2/88	905	265	3.42		22.1			
11/29/88	1139	481	2.37	2.37	42.2	2.38	pre-weatherization	
12/20/88	1037	473	2.19	2.19	49.4			
1/7/89	910	453	2.01	2.01	50.6			
1/31/89	926	578	1.60	1.60	38.6			
2/14/89	773	514	1.50	1.50	55.2			
3/11/89	948	583	1.63	1.63	37.9			
4/5/89	805	440	1.83	1.83	32.2			
5/18/89	414	287	1.44	1.44	9.6			
6/20/89	1131	187	6.05		34.3			
8/5/89	965	72	13.40		21.0			
11/27/89	1587	786	2.02		13.9			
12/16/89	773	443	1.74	1.74	40.7			
1/2/90	850	479	1.77	1.77	50.0			
1/16/90	535	273	1.96	1.96	38.2			
1/27/90	533	298	1.79	1.79	48.5			
2/10/90	636	322	1.98	1.98	45.4			
2/23/90	643	367	1.75	1.75	49.5			
3/15/90	793	382	2.08	2.08	39.7			
4/7/90	656	274	2.39	2.39	28.5			
4/30/90	568	254	2.24	2.24	24.7			
5/30/90	791	254	3.11	3.11	26.4			
6/27/90	528	94	5.62		18.9			
9/5/90	912	15	60.80		13.0			
10/11/90	824	122	6.75		22.9		post-weatherization	
11/7/90	807	356	2.27	2.27	29.9	2.10	pre-O&M	
12/1/90	825	419	1.97	1.97	34.4			
12/20/90	807	494	1.63	1.63	42.5			
12/23/90	239	189	1.26	1.26	79.7			
1/4/91	813	464	1.75	1.75	67.8			
1/9/91	251	186	1.35	1.35	50.2			
1/22/91	559	305	1.83	1.83	43.0			
2/5/91	473	355	1.33	1.33	33.8			
2/19/91	514	244	2.11	2.11	36.7			
3/6/91	547	276	1.98	1.98	36.5			
3/16/91	490	222	2.21	2.21	49.0			
3/27/91	474	222	2.14	2.14	43.1			
5/20/91	1302	691	1.88	1.88	24.1			
6/12/91	483	179	2.70		21.0			
9/3/91	473	7	67.57		5.7	1.79	post-O&M	

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Thrms used/day are approx for , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
Hoyt Street Apts - 4509							
11/6/90	O&M training						
1/2/87	1119						
2/2/87	1162	792	1.47	1.47	38		
3/2/87	1022	564	1.81	1.81	34		
4/2/87	848	488	1.74	1.74	28		
5/2/87	457	341	1.34	1.34	15		
6/2/87	251	170	1.48		8		
7/2/87	187	52	3.60		6		
8/2/87	169	90	1.88		6		
9/2/87	164	2	82.00		5		
10/2/87	163	56	2.91		5		
11/2/87	243	235	1.03		8		
12/2/87	588	502	1.17	1.17	19		
1/5/88	1074	886	1.21	1.21	35		
2/2/88	945	1004	0.94	0.94	31		
3/4/88	831	620	1.34	1.34	27		
4/4/88	777	556	1.40	1.40	26		
5/2/88	573	370	1.55	1.55	19		
6/2/88	493	270	1.83	1.83	16		
7/1/88	285	100	2.85		9		
8/2/88	202	33	6.12		7		
8/30/88	158	15	10.53		5		
9/30/88	254	91	2.79		8		
10/29/88	398	192	2.07		13	1.44	pre-weatherization
12/1/88	831	570	1.46	1.46	27		
1/4/89	953	775	1.23	1.23	31		
2/2/89	720	737	0.98	0.98	24		
3/6/89	1086	939	1.16	1.16	36		
4/3/89	687	498	1.38	1.38	23		
5/2/89	343	239	1.44		11		
6/2/89	377	213	1.77		12		
6/30/89	242	77	3.14		8		
8/1/89	251	45	5.58		8		
8/30/89	259	27	9.59		9		
10/2/89	270	63	4.29		9		
11/89	491	290	1.69	1.69	16		
12/89	656	510	1.29	1.29	22		
1/90	958	801	1.20	1.20	32		
2/90	811	619	1.31	1.31	27		
3/90	911	696	1.31	1.31	30		
4/90	602	426	1.41	1.41	20		
5/90	433	290	1.49	1.49	14		
6/90	435	246	1.77		14		
7/90	279	78	3.58		9		
8/90	191	4	47.75		6		
9/90	132	5	26.40		4		
10/90	153	15	10.20		5		post-weatherization
11/90	455	314	1.45	1.45	15	1.33	pre-O&M
12/90	597	508	1.18	1.18	20		
1/91	1109	1223	0.91	0.91	36		
2/91	922	729	1.26	1.26	30		
3/91	619	525	1.18	1.18	20		
4/91	610	519	1.18	1.18	20		
5/91	485	389	1.25	1.25	16		
6/91	468	324	1.44	1.44	15		

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Thrms used/day are approx for, since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
7/91	228	134	1.70		8		
8/91	156	4	39.00		5		
9/91	148	11	13.45		5	1.20	post-O&M
Hoyt Street Apts - 4411							
10/16/90	O&M training						
1/2/87	642				21		
2/2/87	704	792	0.89	0.89	23		
3/2/87	566	564	1.00	1.00	19		
4/2/87	522	488	1.07	1.07	17		
5/2/87	306	341	0.90	0.90	10		
6/2/87	163	170	0.96		5		
7/2/87	115	52	2.21		4		
8/2/87	117	90	1.30		4		
9/2/87	119	2	59.50		4		
10/2/87	138	56	2.46		5		
11/2/87	186	235	0.79		6		
12/2/87	435	502	0.87	0.87	14		
1/5/88	747	886	0.84	0.84	25		
2/2/88	616	1004	0.61	0.61	20		
3/4/88	548	620	0.88	0.88	18		
4/4/88	487	556	0.88	0.88	16		
5/2/88	323	370	0.87	0.87	11		
6/2/88	297	270	1.10	1.10	10		
7/1/88	143	100	1.43		5		
8/2/88	135	33	4.09		4		
8/30/88	119	15	7.93		4		
9/30/88	172	91	1.89		6		
10/29/88	190	192	0.99		6	0.90	pre-weatherization
12/1/88	540	570	0.95	0.95	18		
1/4/89	578	775	0.75	0.75	19		
2/2/89	431	737	0.58	0.58	14		
3/6/89	646	939	0.69	0.69	21		
4/3/89	434	498	0.87	0.87	14		
5/2/89	213	239	0.89		7		
6/2/89	183	213	0.86		6		
6/30/89	116	77	1.51		4		
8/1/89	111	45	2.47		4		
8/30/89	104	27	3.85		3		
10/2/89	244	63	3.87		8		
11/89	150	290	0.52	0.52	5		
12/89	403	510	0.79	0.79	13		
1/90	582	801	0.73	0.73	19		
2/90	514	619	0.83	0.83	17		
3/90	585	696	0.84	0.84	19		
4/90	374	426	0.88	0.88	12		
5/90	281	290	0.97	0.97	9		
6/90	298	246	1.21		10		
7/90	163	78	2.09		5		
8/90	127	4	31.75		4		
9/90	96	5	19.20		3		
10/90	145	15	9.67		5		post-weatherization
11/90	323	314	1.03	1.03	11	0.79	pre-O&M
12/90	480	508	0.94	0.94	16		
1/91	760	1223	0.62	0.62	25		
2/91	496	729	0.68	0.68	16		

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Thrms used/day are approx for , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
3/91	391	525	0.74	0.74	13		
4/91	428	519	0.82	0.82	14		
5/91	350	389	0.90	0.90	12		
6/91	277	324	0.85	0.85	9		
7/91	140	134	1.04		5		
8/91	109	4	27.25		4		
9/91	97	11	8.82		3	0.77	post-O&M

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Therm's used/day are approx for, since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
Claremont - 4115 SE Morrison							
11/2/90	O&M training						
1/7/88	2843				94		
2/5/88	2186	1037	2.11	2.11	72		
3/8/88	1857	613	3.03	3.03	61		
4/6/88	1561	508	3.07	3.07	51		
5/5/88	1174	384	3.06	3.06	39		
6/6/88	1029	256	4.02	4.02	34		
7/7/88	424	88	4.82		14		
8/4/88	194	8	24.25		6		
9/6/88	227	15	15.13		7		
10/4/88	549	101	5.44		18		
11/2/88	1052	224	4.70		35		
12/6/88	2011	636	3.16	3.16	66		
1/9/89	2383	781	3.05	3.05	78		
2/6/89	2292	787	2.91	2.91	75		
3/8/89	2396	787	3.04	3.04	79		
4/6/89	1856	486	3.82	3.82	61		
5/6/89	1080	200	5.40		36	3.20	pre-weatherization
6/6/89	1027	205	5.01		34		
11/89	1177	319	3.69	3.69	39		
12/89	1759	543	3.24	3.24	58		
1/90	2261	790	2.86	2.86	74		
2/90	2345	660	3.55	3.55	77		
3/90	2223	643	3.46	3.46	73		
4/90	1347	392	3.44	3.44	44		
5/90	1242	294	4.22	4.22	41		
6/90	1267	239	5.30		42		
7/90	696	57	12.21		23		
8/90	218	3	72.67		7		
9/90	246	5	49.20		8		
10/90	259	27	9.59		9		post-weatherization
11/90	1257	356	3.53	3.53	41	3.50	pre-O&M
12/90	1772	557	3.18	3.18	58		
1/91	2879	1074	2.68	2.68	95		
2/91	1861	650	2.86	2.86	61		
3/91	1648	510	3.23	3.23	54		
4/91			#DIV/0!		0		data missing
5/91	1241	350	3.55	3.55	41		
6/91	1225	302	4.06	4.06	40		
7/91	755	110	6.86		25		
8/91	232	4	58.00		8		
9/91	215	15	14.33		7	3.26	post-O&M

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Therms used/day are approx for , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
Claremont - 815 SE 42nd							
10/30/90	O&M training						
1/7/88	3401				112		
2/5/88	2652	1037	2.56	2.56	87		
3/8/88	2165	613	3.53	3.53	71		
4/6/88	1890	508	3.72	3.72	62		
5/5/88	1515	384	3.95	3.95	50		
6/6/88	1183	256	4.62	4.62	39		
7/7/88	479	88	5.44		16		
8/4/88	281	8	35.13		9		
9/6/88	342	15	22.80		11		
10/4/88	593	101	5.87		20		
11/2/88	1188	224	5.30		39		
12/6/88	2553	636	4.01	4.01	84		
1/9/89	3104	781	3.97	3.97	102		
2/6/89	2924	787	3.72	3.72	96		
3/8/89	3011	787	3.83	3.83	99		
4/6/89	2234	486	4.60	4.60	73		
5/6/89	1059	200	5.30		35	4.03	pre-weatherization
6/6/89	1184	205	5.78		39		
11/89	1822	319	5.71	5.71	60		
12/89	2220	543	4.09	4.09	73		
1/90	2727	790	3.45	3.45	90		
2/90	2826	660	4.28	4.28	93		
3/90	1618	643	2.52	2.52	53		
4/90	2573	392	6.56	6.56	85		
5/90	1482	294	5.04	5.04	49		
6/90	1471	239	6.15		48		
7/90	685	57	12.02		23		
8/90	283	3	94.33		9		
9/90	307	5	61.40		10		
10/90	330	27	12.22		11		post-weatherization
11/90	1466	356	4.12	4.12	48	4.47	pre-O&M
12/90	2275	557	4.08	4.08	75		
1/91	3598	1074	3.35	3.35	118		
2/91	2396	650	3.69	3.69	79		
3/91	2026	510	3.97	3.97	67		
4/91			#DIV/0!		0	data missing	
5/91	1643	350	4.69	4.69	54		
6/91	1450	302	4.80		48		
7/91	721	110	6.55		24		
8/91	298	4	74.50		10		
9/91	262	15	17.47		9	3.96	post-O&M

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Therms used/day are approx for, since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
Lowsdale - 218 SW Salmon							
11/30/90	O&M training						
10/1/89	1222	213	5.74		40		
11/1/89	1777	520	3.42	3.42	58		
12/1/89	3234	726	4.45	4.45	106		
1/1/90	3971	653	6.08	6.08	131		
2/1/90	4083	740	5.52	5.52	134		
3/1/90	2084	454	4.59	4.59	69		
4/1/90		282	0.00		0		
5/1/90	2227	280	7.95		73		
6/1/90	1165	107	10.89		38		
7/1/90	895	10	89.50		29		
8/1/90	632	5	126.40		21		
9/1/90	787	9	87.44		26		
10/1/90	1429	265	5.39	5.39	47		
11/1/90	2422	482	5.02	5.02	80	4.93	
12/1/90	3466	855	4.05	4.05	114		
1/1/91	3633	873	4.16	4.16	120		
2/1/91	1947	516	3.77	3.77	64		
3/1/91	2092	557	3.76	3.76	69		
4/1/91	0	0	#DIV/0!		0	data missing	
5/1/91	3177	734	4.33	4.33	105		
6/1/91	826	183	4.51		27		
7/1/91	502	10	50.20		17		
8/1/91	582	5	116.40		19	4.01	
9/1/91							
Babette - 2623 SE Ankeny							
11/29/90	O&M training						
10/1/89							
11/1/89	1067	356	3.00	3.00	35		
12/1/89	1621	523	3.10	3.10	53		
1/1/90	2295	785	2.92	2.92	75		
2/1/90	2016	675	2.99	2.99	66		
3/1/90	457	634	0.72		15		
4/1/90	1265	419	3.02	3.02	42		
5/1/90	1248	260	4.80	4.80	41		
6/1/90	855	232	3.69		28		
7/1/90	503	52	9.67		17		
8/1/90	341	3	113.67		11		
9/1/90	310	5	62.00		10		
10/1/90	408	40	10.20		13		
11/1/90	1170	384	3.05	3.05	38	3.27	
12/1/90	1616	540	2.99	2.99	53		
1/1/91	2775	1082	2.56	2.56	91		
2/1/91	1644	635	2.59	2.59	54		
3/1/91	1555	558	2.79	2.79	51		
4/1/91	1153	497	2.32	2.32	38		
5/1/91	1030	347	2.97	2.97	34		
6/1/91	1215	292	4.16	4.16	40		
7/1/91	736	107	6.88		24		
8/1/91	405	2	202.50		13	2.91	
9/1/91	461	15	30.73		15		

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Therms used/day are approx for , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
Danmore Hotel - 1217 SW Morrison							
11/2/90	O&M training						
10/1/89	2654	213	12.46		87		
11/1/89	5619	520	10.81	10.81	185		
12/1/89	6666	726	9.18	9.18	219		
1/1/90	6838	653	10.47	10.47	225		
2/1/90	8411	740	11.37	11.37	277		
3/1/90	4595	454	10.12	10.12	151		
4/1/90	2792	282	9.90	9.90	92		
5/1/90	2846	280	10.16	10.16	94		
6/1/90	1978	107	18.49		65		
7/1/90	1683	10	168.30		55		
8/1/90	1328	5	265.60		44		
9/1/90	1547	9	171.89		51		
10/1/90	2890	265	10.91	10.91	95		
11/1/90	5180	482	10.75	10.75	170	10.41	
12/1/90	7653	855	8.95	8.95	252		
1/1/91	6688	873	7.66	7.66	220		
2/1/91	6649	516	12.89	12.89	219		
3/1/91	4673	557	8.39	8.39	154		
4/1/91	4057	405	10.02	10.02	133		
5/1/91	3457	329	10.51	10.51	114		
6/1/91	2031	183	11.10		67		
7/1/91	1732	10	173.20		57		
8/1/91	1670	5	334.00		55	9.74	
9/1/91							
CONTROL Knob Hill Apts							
Count 12/90 and after as an equivalent post-O&M period for controls							
10/1/89							
11/1/89	1566	395	3.96	3.96	52		
12/1/89	3199	693	4.62	4.62	105		
1/1/90	3439	768	4.48	4.48	113		
2/1/90	3188	740	4.31	4.31	105		
3/1/90	2475	472	5.24	5.24	81		
4/1/90	1174	283	4.15	4.15	39		
5/1/90	1787	324	5.52	5.52	59		
6/1/90	1179	144	8.19		39		
7/1/90	776	7	110.86		26		
8/1/90	305	3	101.67		10		
9/1/90	314	10	31.40		10		
10/1/90	1240	186	6.67		41		
11/1/90	1961	385	5.09	5.09	65	4.67	
12/1/90	3320	707	4.70	4.70	109		
1/1/91	5097	1036	4.92	4.92	168		
2/1/91	3447	584	5.90	5.90	113		
3/1/91	3223	546	5.90	5.90	106		
4/1/91	2391	448	5.34	5.34	79		
5/1/91	1937	328	5.91	5.91	64		
6/1/91	1483	221	6.71		49		
7/1/91	585	39	15.00		19		
8/1/91	281	1	281.00		9	5.44	
9/1/91							

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Thrms used/day are approx 4 er , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
CONTROL Glen Court Apts							
Count 12/90 and after as an equivalent post-O&M period for controls							
10/1/89							
11/1/89	269	376	0.72		9		
12/1/89	1099	613	1.79		36		
1/1/90	2130	784	2.72	2.72	70		
2/1/90	2041	711	2.87	2.87	67		
3/1/90	1976	575	3.44	3.44	65		
4/1/90	1049	291	3.60	3.60	35		
5/1/90	1023	307	3.33	3.33	34		
6/1/90	882	180	4.90		29		
7/1/90	405	7	57.86		13		
8/1/90	261	3	87.00		9		
9/1/90	285	10	28.50		9		
10/1/90	718	158	4.54		24		
11/1/90	1176	379	3.10	3.10	39	3.18	
12/1/90	1648	675	2.44	2.44	54		
1/1/91	2747	999	2.75	2.75	90		
2/1/91	1808	653	2.77	2.77	59		
3/1/91	2008	543	3.70	3.70	66		
4/1/91	1603	456	3.52	3.52	53		
5/1/91	1323	316	4.19	4.19	44		
6/1/91	1155	242	4.77		38		
7/1/91	565	58	9.74		19		
8/1/91	304	1	304.00		10	3.23	
9/1/91							
CONTROL Margot Apts							
Count 12/90 and after as an equivalent post-O&M period for controls							
10/1/89							
11/1/89	865	363	2.38	2.38	28		
12/1/89	1340	528	2.54	2.54	44		
1/1/90	1854	794	2.34	2.34	61		
2/1/90	1516	673	2.25	2.25	50		
3/1/90	1839	685	2.68	2.68	60		
4/1/90	1076	354	3.04	3.04	35		
5/1/90	977	258	3.79	3.79	32		
6/1/90	993	230	4.32		33		
7/1/90	316	49	6.45		10		
8/1/90	201	3	67.00		7		
9/1/90	204	5	40.80		7		
10/1/90	203	80	2.54		7		
11/1/90	765	362	2.11	2.11	25	2.64	
12/1/90	1153	550	2.10	2.10	38		
1/1/91	2279	1082	2.11	2.11	75		
2/1/91	1220	626	1.95	1.95	40		
3/1/91	1262	558	2.26	2.26	42		
4/1/91	1220	498	2.45	2.45	40		
5/1/91	956	341	2.80	2.80	31		
6/1/91	696	278	2.50	2.50	23		
7/1/91	382	106	3.60		13		
8/1/91						2.31	
9/1/91							

Apartment O&M Savings Analysis - GAS

Date	thrms	D-Days	thrms per D-day*	winter gal/DD*	thrms used per day**	AVG thrms per D-day	% savings
* Only the "winter" D-Days are included in averages.							
** Therms used/day are approx for , since all assume 30.4 days (dates not incl. in some gas data), shown for ref only							
CONTROL Alder St Apts							
Count 12/90 and after as an equivalent post-O&M period for controls							
10/1/89	986	213	4.63		32		
11/1/89	2180	520	4.19	4.19	72		
12/1/89	2978	726	4.10	4.10	98		
1/1/90	2901	653	4.44	4.44	95		
2/1/90	3827	740	5.17	5.17	126		
3/1/90	2396	454	5.28	5.28	79		
4/1/90	2078	282	7.37	7.37	68		
5/1/90	2427	280	8.67		80		
6/1/90	2189	107	20.46		72		
7/1/90	1148	10	114.80		38		
8/1/90	1111	5	222.20		37		
9/1/90	1944	9	216.00		64		
10/1/90	2130	265	8.04		70		
11/1/90	3004	482	6.23	6.23	99	5.26	
12/1/90	5082	855	5.94	5.94	167		
1/1/91	4260	873	4.88	4.88	140		
2/1/91	3493	516	6.77	6.77	115		
3/1/91	2878	557	5.17	5.17	95		
4/1/91	2438	405	6.02	6.02	80		
5/1/91	2346	329	7.13	7.13	77		
6/1/91	2012	183	10.99		66		
7/1/91	2120	10	212.00		70		
8/1/91	1689	5	337.80		56	5.99	
9/1/91							

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