ENERGY CENTER OF WISCONSIN

ECW Report Number 232-1

Energy and Rental Housing

A Wisconsin characterization study

April 2005

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REPORT SUMMARY

This study characterizes Wisconsin rental housing in energy-related terms. It is based on a statewide sample of 180 rental properties, ranging from single-family rental homes to large apartment buildings. The findings are based on detailed on-site audit data that were gathered for each building, along with owner/manager and tenant survey, as well as utility usage history data. While other more limited energy characterizations of Wisconsin rental properties have been conducted in the past, this is the first study with a statewide perspective embracing the full range of rental housing in the state.

In many ways Wisconsin rental housing can be divided into two distinct varieties: single-family and small multifamily buildings (2-4 units), and larger multifamily properties with five or more rental units. Small properties make up more than 50 percent of the 658,000 rental housing units in the state, and constitute more than 90 percent of the estimated 278,000 Wisconsin rental buildings. These properties tend to be older, and use more heating energy per square foot than owner-occupied homes. About 70 percent of rental-sector electricity and natural gas use is consumed in these smaller buildings, and nearly all of this use is paid directly by tenants. Not surprisingly, of the energy efficiency opportunities identified by this study, about 70 percent were found to reside in these small properties.

The heating and water heating equipment in smaller properties tends to be that of owner-occupied housing: individual furnaces and water heaters. However, a significant minority of small multifamily properties are heated by boilers, electric baseboard or other means. Tenants of these buildings are in general more likely to report comfort problems than either tenants of larger rental properties or owner-occupied homes.

Individual owners overwhelmingly manage and make weatherization and equipment decisions regarding these smaller properties. Because tenants pay for more than 90 percent of the energy costs directly, utility costs do not represent a significant proportion of the operating costs for most of these owners. This makes the so-called split incentive problem particularly vexing for this segment of rental housing: landlords have little incentive to invest in improving energy efficiency since they do not reap the benefits, and tenants—who pay the utility bills—have little control or decision-making ability related to energy efficiency improvements.

Larger multifamily buildings constitute somewhat less than half of the rental housing units in the state; most of these buildings were built after 1970. Partly because of this—but also because they enclose a larger volume per square foot of surface area—these apartment buildings use far less heating energy per square foot than smaller buildings. Moreover, because apartments in these buildings tend to be occupied by smaller households (about half are single-person households) with fewer energy-using appliances, non space-conditioning electricity use is also considerably lower. Overall, about 30 percent of the electricity and natural gas used in the Wisconsin rental sector is consumed in these larger properties. In contrast to smaller rental properties, landlords foot the bill for more than 95 percent of the total natural gas consumption in these buildings and 40 percent of electricity use. This is partly due to the fact that nearly all of these larger properties have common areas that require space conditioning and lighting.

Heating in these buildings is dominated by natural gas boilers, though a significant minority of electric baseboard heat and individual gas furnaces are also found in Wisconsin. Water heating is most likely to be accomplished with a natural-gas fired central tank water heater, though more than a quarter of 20+ unit properties use a boiler sidearm to supply domestic hot water.

Larger rental properties in Wisconsin, like smaller ones, tend to be owned by individual investors. However management and decision-making is spread over a larger cast of on- and off-site managers, maintenance staff and others who may be employees of a separate management firm.

Air conditioning equipment is found in about four out of five Wisconsin rental households. It is most likely to be present in large buildings, and least likely to be present in single-family rental housing. The dominant type of air conditioning equipment (for all building sizes) is a window or sleeve room air conditioner. In single-family and small multifamily buildings, these are mostly provided by the tenant; landlords mostly provide the units in larger buildings.

Wisconsin landlords purchase about 40,000 refrigerators annually in the state. Because of the large number of apartments involved, appliance replacement is a relatively common activity in larger buildings. Not surprisingly, refrigerators in larger buildings thus tend to be somewhat newer than those in smaller rental properties and owner-occupied housing. Nonetheless, short-term monitoring of refrigerators in sampled apartments indicates that the typical refrigerator in a Wisconsin apartment uses about 800 kWh per year—about twice what a new Energy Star labeled unit of comparable size consumes.

An analysis of 24 energy efficiency opportunities shows that relatively low-cost lighting and water heating measures dominate the aggregate savings potential for measures with a 5-year payback or less. While most common-area lighting and exit signs in large buildings (20+ units) have already been upgraded to higher efficiency fluorescent bulbs (or LED, in the case of exit signs), a substantial amount of incandescent lighting still exists in smaller multifamily common areas. Lighting in apartment units is nearly all incandescent, and represents a largely untapped area of opportunities for energy efficiency improvements—albeit a more difficult one to address.

Opportunities also exist for heating system efficiency upgrades for larger buildings and building shell improvements for smaller properties, but these require a higher capital investment and have a longer payback period.

Overall, the study points toward significant opportunities for improving the energy efficiency of the Wisconsin rental sector. The challenge will be to find mechanisms to realize this potential, given that much of it is spread among a large number of small rental properties where landlords control the decision-making but tenants largely pay the utility bills.

INTRODUCTION

BACKGROUND AND OBJECTIVE

About a quarter of Wisconsin's population of 5.4 million people lives in rental housing. Because rental households tend to be somewhat smaller than owner-occupied households, this quarter of the population occupies just under a third of the housing units in the state—about 658,000 rental housing units. Rental housing in the state ranges from mobile homes in the rural northwest corner of the state to high-rise apartment buildings in downtown Milwaukee. Though the term "rental housing" brings to mind apartment buildings with many tenants, in fact more than a quarter of rental housing units in the state are single-family detached buildings, and nearly half are single-family homes or duplexes.

Over the years, a number of utilities have implemented programs aimed at improving the energy efficiency of rental housing. More recently the state, through its Apartment and Condominium Efficiency Services program under the Focus on Energy umbrella, has taken on the challenge of improving the energy efficiency in buildings with four or more units. During the first three years of operation the Focus program has been credited with 1.7 million therms and 25 million kWh in annual savings.

Reducing energy use in the rental sector has traditionally been viewed as more challenging than efforts geared toward owner-occupied homes because of the so-called split-incentives problem. Simply put, landlords often have little incentive to invest in more efficient heating systems and appliances because tenants pay the bills (either directly or indirectly). Conversely, tenants—who pay the energy bills—have no ownership interest in the building or its equipment and appliances, and have little or no decision-making authority related to energy efficiency improvements.

Though a number of studies of energy use in Wisconsin rental housing have been conducted in the past, no comprehensive statewide characterization of Wisconsin rental housing from an energy perspective has ever been attempted. To provide a more solid basis of understanding of energy use and energy efficiency options in the Wisconsin rental sector—as well as to provide a baseline for judging efforts under the Focus program—Focus on Energy and utility members of the Energy Center of Wisconsin have jointly funded this characterization study of Wisconsin rental housing.

This study complements a similar study of single-family owner-occupied homes in Wisconsin conducted in 1999.[1] As such, the study has the following objectives:

- Provide a statistically representative picture of building characteristics, appliances and equipment in Wisconsin rental housing.
- Benchmark energy usage in rental housing.
- Assess energy efficiency opportunities in the rental sector.

[1] *Energy and Housing: A Study of Single-Family Owner-Occupied Homes,* Energy Center of Wisconsin Research Report 199-1, 199-2, November 2000. Available from www.ecw.org.

- Explore linkages between energy efficiency opportunities; and knowledge, attitudes and behavior on the part of building tenants, owners and managers.

Taken together, these two studies provide a comprehensive assessment of Wisconsin housing stock at the beginning of the 21st century.

METHOD

The approach to the study was to gather on-site and other data from a statistically representative sample of Wisconsin rental buildings. The study had an overall target of 180 rental buildings, and was designed to include all rental housing, from single-family homes to large multifamily buildings. At the same time, most program efforts in the rental sector have been geared toward buildings with four or more rental units. We therefore implemented a sampling plan that called for a relatively equal number of buildings in each of seven size categories, based on the number of dwelling units in the building.

This approach places more emphasis on larger properties. In particular, buildings with 10 or more units make up 40 percent of the study sample, but constitute less than five percent of the statewide population of rental buildings. Conversely, buildings with two or fewer housing units make up only 30 percent of the study sample, but represent more than 85 percent of the rental buildings in the state. We used Census 2000 data to weight the sample so that each building in the study sample represented the proportionate number of buildings in the size category. We also weighted the sample to properly represent the geographic distribution of rental housing in the state.

We recruited the buildings for the study from two sources: (1) a statewide list of rental properties identified during the course of implementing several prior random telephone surveys of Wisconsin residents, and (2) lists of rental properties from community tax rolls for communities that were themselves randomly sampled.

Figure 1 shows the range of buildings recruited for the study. These ran the gamut of Wisconsin rental housing: from a converted chicken coop to a luxury high-rise in downtown Milwaukee. The final study sample of 180 buildings includes between 20 and 29 buildings in each of the seven size strata. Appendix A provides more detail about the sampling and recruiting process for the study.

We gathered three types of data for each building recruited for the study:

1. **On-site data** — Trained auditors gathered on-site data on the building itself, mechanical systems, appliances and lighting characteristics. The on-site data collection also included in-unit data collection for a sample of units in each building, including short-term monitoring of refrigerator electricity use.
2. **Survey data** — We administered a written questionnaire to building owners and managers to capture information about ownership of the building, purchasing and maintenance practices and other information. A separate questionnaire dealing with demographics, attitudes, comfort and energy-saving behaviors was administered to tenants in the sampled buildings.
3. **Utility usage records** — We collected utility electricity and natural gas usage histories for both master-metered accounts paid by landlords and individually-metered accounts paid by tenants.

FIGURE 1. SMALLEST, LARGEST AND TYPICAL STUDY BUILDINGS BY SIZE CATEGORY

	Smallest	Median	Largest
Single-family			
Duplex			
3-4 Units			
5-9 Units			
10-19 Units			
20-49 Units			
50+ Units			

Appendix F contains the data collection instruments used in the study.

We attempted to obtain a completed owner/manager questionnaire from all participants in the study and provided a $100 incentive to respondents, but some landlords did not return the survey despite repeated requests. The final data set includes 161 completed questionnaires, for a response rate of 89 percent.

Except for the largest buildings, we delivered tenant questionnaires to the door of all tenants in each sampled building. In buildings with more than 20 units, a random sample of 20 tenants received a questionnaire. We offered tenants a $15 incentive for returning a completed questionnaire and utility fuel data release form. We received 748 out of 1,613 back, for a completion rate of 46 percent.

We also used the owner/manager and tenant questionnaire data to classify buildings according to whether they were predominately occupied by low-income tenants. The procedure we used to do so is documented in Appendix B. The goal of this analysis was to establish a segment of the study sample comprising buildings where 50 percent or more of the tenant households had incomes at or below 150 percent of the Federal Poverty Guideline, excluding student housing. The analysis used a combination of data on household size and income reported by respondents to the tenant survey and responses provided by landlords to survey questions about the composition of tenants in the sampled building.

FINDINGS

The comprehensive data collected for the study provide many important insights into energy use in rental housing. We present these findings in the sections that follow, beginning with an overview of the composition of rental housing in the state from Census 2000 data and the on-site study data. This is followed by sections that characterize the buildings and equipment in the study sample in terms of building shells, heating, cooling and water heating equipment, lighting, and appliances.

We also present the results of an analysis of natural gas and electricity usage histories for study participants, along with an examination of the prevalence of energy efficiency opportunities in rental housing in the state.

The final sections of the report examine tenant demographics, attitudes and behaviors and look at building ownership, management and decision-making attributes related to energy use and energy efficiency.

Results tables in the sections below generally are broken out by building size, as well as for low-income and non low-income buildings, and also according to whether the tenants directly pay the bills for the space heating fuel. Caution is required in interpreting the last: tenants are much more likely to be responsible for the heating bill in smaller buildings than larger buildings.

COMPOSITION OF WISCONSIN RENTAL HOUSING

Wisconsin's rental housing is concentrated in the southern and eastern portions of the state, as is the population as a whole (Figure 2). Overall, Wisconsin's 658,000 rental housing units constitute 24 percent of all state housing units, though this percentage varies somewhat regionally, from 17 percent in the north to 27 percent in the southeast.

Single-family rental homes and small multifamily buildings (2-4 units) make up more than half of all rental housing units and more than 90 percent of rental buildings (Table 1). While the number of apartment buildings with five or more units is relatively small, these buildings make up nearly 40 percent of the total rental floor space. Though buildings with more units are larger in an absolute sense, the amount of floor space per dwelling unit tends to decline as the number of dwelling units in the building increases (Table 2), even if common areas are included.

When it comes to building age, there is a clear dichotomy between small rental buildings and larger apartment buildings. Single-family homes and small multifamily buildings predominately date to the 1940s or earlier. In contrast, most large multifamily buildings were built in the 1970s or later, and a significant fraction of mid-size buildings (5 – 19 units) are less than 20 years old (Table 2)

FIGURE 2. WISCONSIN RENTAL HOUSING UNITS

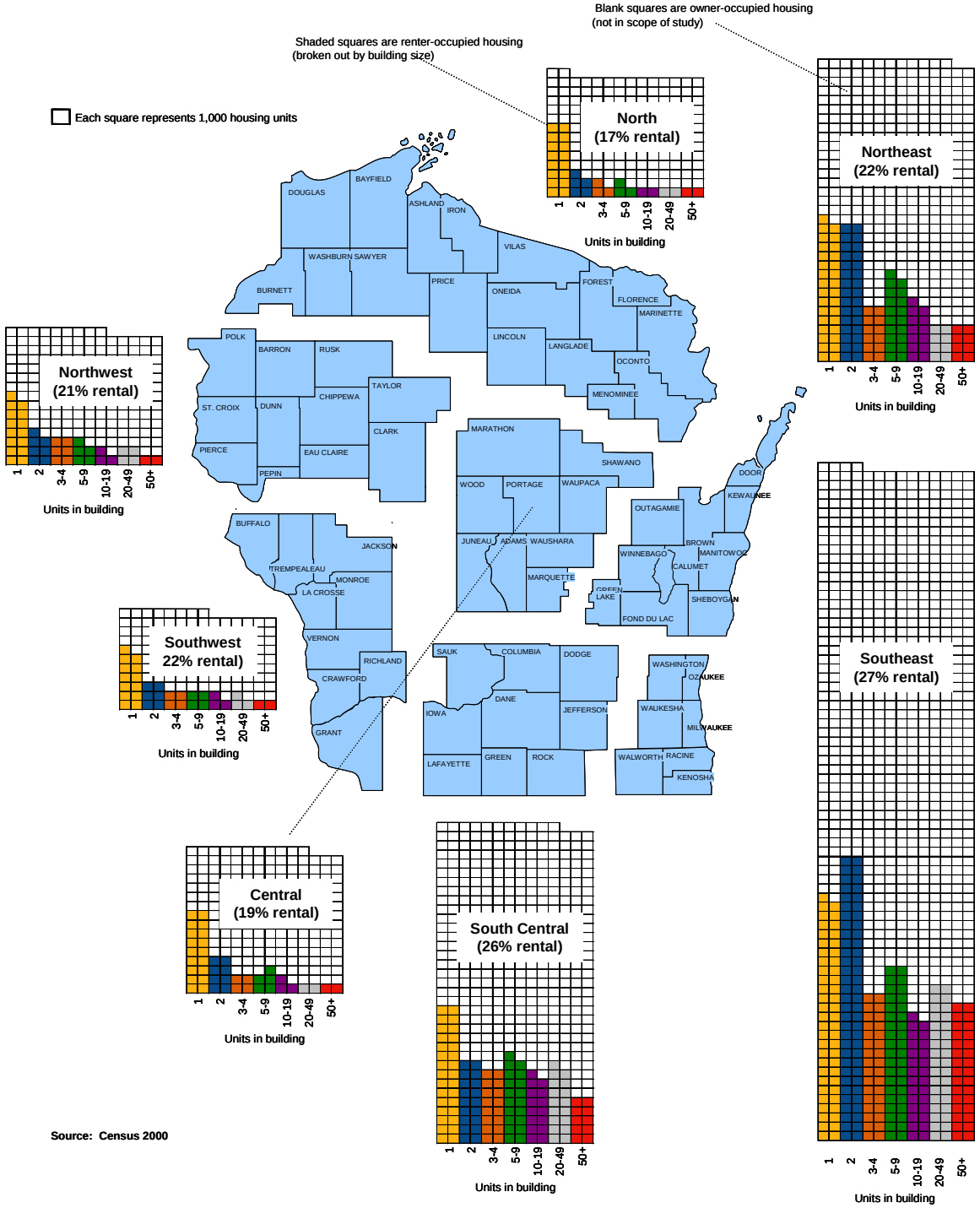


TABLE 1. RENTAL HOUSING UNITS, BUILDINGS AND FLOOR AREA, BY NUMBER OF UNITS IN STRUCTURE.

UNITS IN STRUCTURE	HOUSING UNITS	(%)	BUILDINGS	(%)	FLOOR AREA[a] (MILLION FT^2)	(%)
1	171,200	26	171,200	62	216	30
2	131,600	20	65,800	24	150	21
3-4	75,200	11	20,000	7	74	10
5-9	90,400	14	12,800	5	101	14
10-19	65,300	10	4,900	2	60	8
20-49	69,500	11	2,500	<1	60	8
50+	54,800	8	600	<1	61	9
Total Rental	658,000	100	277,800	100	721	100
Rental as a % of all WI housing	24%		17%		17-24%[b]	

[a]Includes common areas for multifamily buildings

[b]Lower figure is based on including basements for single-family owner-occupied homes; upper figure excludes basements.

Note: housing units from Census 2000; buildings and floor area based on study sample weighted to Census housing unit counts.

TABLE 2. AVERAGE BUILDING CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		ALL BLDGS
	1	**2-4**	**5-19**	**20+**	**YES**	**NO**	**YES**	**NO**	
Total Building									
Floor area									
ft^2	1,300	2,600	9,000	39,100	1,900	3,200	2,000	8,600	2,600
ft^2/dwelling unit[a]	1,310	1,100	1,000	910	1,170	1,260	1,240	1,040	1,200
Volume									
ft^3	10,900	23,400	76,900	341,700	17,300	27,400	17,600	75,000	22,400
ft^3/dwelling unit[a]	10,950	9,930	8,540	7,800	10,320	10,570	10,580	9,000	102,30
% of buildings w/ common areas	0	66	86	100	100	77	54	97	71
Dwelling Units									
Units in bldg	1	2	9	40	2	3	2	8	2
ft^2/dwelling unit[b]	1,290	920	870	730	980	950	1070	770	960
Building vintage (%)									
Pre1930	42%	58%	12%	6%	42%	47%	44%	49%	45%
1930s	8%	3%	3%	0%	11%	4%	6%	6%	6%
1940s	29%	0%	4%	0%	32%	10%	20%	2%	18%
1950s	6%	2%	14%	2%	1%	5%	5%	10%	5%
1960s	5%	21%	6%	11%	8%	10%	10%	11%	10%
1970s	0%	12%	8%	29%	3%	4%	4%	5%	4%
1980s	9%	1%	10%	35%	1%	12%	8%	2%	7%
1990+	0%	4%	43%	17%	1%	7%	3%	16%	4%
Study sample	29	49	56	46	46	125	107	72	180

[a]Includes common areas.

[b]Based on measurements for sampled units within building. Does not include common areas

CHARACTERISTICS OF BUILDINGS AND EQUIPMENT

Building Shell

The building envelope is the exterior shell of the building that includes the walls, doors, windows, ceilings, and floors, and separates the livable space from the outdoors. Heat passes through the building envelope either by infiltration, or by direct heat transfer through the components.

Table 3 summarizes the characteristics of building shells in Wisconsin rental housing. We collected data on the area insulation level of the wall and ceiling spaces whenever possible[2]. Most rental buildings have some ceiling insulation, and about a quarter have ceilings insulated to R-38 or more. This fraction is similar to that for single-family, owner-occupied homes. Large apartments are the most likely to have substantial levels of ceiling insulation. In contrast more than a third of single-family rental homes (based on the limited sample of 19 in the study) do not have even R-19 ceiling insulation. Low income rental units are also less likely to have substantial ceiling insulation. Most buildings have some ceiling insulation, however, we found only one building that had no ceiling insulation whatsoever.

Though limited data could be gathered on wall insulation, the results suggest that only about four percent of all rental buildings have walls that are uninsulated—a figure that is below that for single-family, owner-occupied homes (11%).

Blower door tests were performed in single-family buildings and duplexes to measure air leakage. The results showed an average of 0.72 estimated natural air changes per hour (ACH) for single-family buildings, and 0.77 natural ACH for duplexes, though the latter also includes leakage into adjacent units.[3] These averages are nearly twice the leakage rates measured for single-family owner-occupied homes in the earlier study. Among the single-family buildings measured for this study, leakage rates ranged from about one-third to one estimated natural ACH, with a standard deviation of about 0.2 estimated natural ACH.

The study collected information on the type and total area of windows within each rental building (Table 4). Overall, windows account for about 12 percent of the gross wall area of all rental buildings. However, windows make up a substantially larger fraction of the wall area for larger buildings. The most common type of window found was single hung followed closely by double hung. More than three-quarters of all windows were one of these two types. Sliding type windows accounted for just under 10% of all windows, however, this type of window is found more than a third of the time in buildings with 20 or more units.

[2] Not all landlords gave permission for us to drill holes into the wall to collect this information, and some attic areas were not accessible. Wall insulation data was ascertained in just over half of the study participants and ceiling insulation data was collected in about two-thirds of the buildings.
[3] Natural air changes per hour were roughly estimated as ACH @ 50 Pascals divided by 20.

The most common pane and frame type is single pane wood with storm – about one-half of all windows in rental buildings. This type of window is much more prevalent in single-family rental units (62%) than in large buildings of over 20 units (only 10%). Buildings with 20 units or more have more double pane metal style windows than any other type (39%).

TABLE 3. BUILDING SHELL CHARACTERISTICS (EXCLUDING WINDOWS)

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	YES	NO	
Walls									
Area (avg. ft^2)									
Building total	1,530	2,431	5,064	16,178	1,921	2,440	1,955	4,585	2,196
Per dwelling unit	1,530	1,047	609	404	1,313	1,303	1,356	827	1,309
% uninsulated[a,b]	8	4	7	0	0	6	3	6	7
Ceilings									
Area (avg. ft^2)									
Building total	854	1,610	4,276	14,187	1,078	1,735	1,252	3,495	1,454
Per dwelling unit	854	695	488	400	669	823	804	494	776
Insulation level(%)[a,c]									
% <R-19	42	18	9	9	34	30	32	21	30
% R-19 to R-37	33	63	38	52	55	30	44	49	44
% R-38+	25	19	53	40	11	40	25	30	25
Foundation									
% basement	94	88	51	51	94	85	91	72	89
% crawlspace	6	0	0	2	0	6	4	0	3
% mixed	0	10	9	20	6	4	4	10	4
% slab	0	1	40	28	0	5	2	18	3

Notes:

[a]Percent of aggregate statewide area.

[b]Wall insulation could not be ascertained for all buildings. The number of sites with wall insulation data is: single family, 17; 2-4 unit, 27; 5-19 unit, 25; and, 20+ unit, 25.

[c]Ceiling insulation could not be ascertained for all buildings. The number of sites with ceiling insulation data is: single family, 19; 2-4 unit, 34; 5-19 unit, 40; and, 20+ unit, 26.

TABLE 4. WINDOW CHARACTERISTICS

			UNITS IN BUILDING				LOW-INCOME BUILDING?		ALL BLDGS
			1	2-4	5-19	20+	YES	NO	
Windows									
Mean total area (ft^2)			157	283	854	3,360	221	336	284
(ft^2 per unit)			157	120	102	80	129	148	140
Mean area as % gross wall area			11	12	19	31	11	13	12
Type (%)									
Double Hung			47	36	25	18	21	44	37
Single Hung			34	42	45	33	51	33	39
Fixed Glass			10	9	2	8	10	8	8
Awning Hopper			5	3	8	3	7	3	4
Casement			2	2	3	2	2	2	2
Sliding			2	7	16	34	9	10	9
Panes and Frames (%)									
Single pane	Wood	Storm	62	52	41	10	61	43	51
		No storm	8	5	8	6	13	3	6
	Vinyl	Storm	<1	<1	1	<1	1	<1	<1
		No storm	0	0	0	0	0	0	0
	Metal	Storm	7	5	3	20	8	7	7
		No storm	0	5	2	2	<1	3	2
Double pane	Wood		8	10	4	10	5	10	8
	Metal		3	18	20	39	5	20	14
	Vinyl		10	4	21	9	7	12	10
Triple pane	Wood		0	0	1	4	0	1	<1

Space Heating

Table 5 summarizes the characteristics of the heating systems encountered in the study. Statewide, more than two-thirds of renters pay their heating bills directly. Most are renters in single-family homes and small multifamily buildings, but more than a third of renters in larger apartment buildings pay their heating bills directly–more than half of these tenants have electric resistance heating.

Natural gas is the fuel of choice for space heating in Wisconsin rental housing, used in more than 80 percent of rental buildings. Natural gas typically fuels both the forced air furnaces found in smaller rental buildings, and hydronic boilers that are common in larger buildings.

In the following sections, we review some characteristics of the three dominant heating system types in the state.

TABLE 5. SPACE HEATING CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?[a]		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	YES	NO	
Who pays the heat?									
Tenants	100%	84%	44%	49%	98%	85%			91%
Landlord	0%	15%	56%	51%	2%	14%			9%
Mix in same bldg	0%	1%	0%	0%	0%	<1%			<1%
Heating fuel									
Natural gas	85%	84%	72%	59%	93%	79%	83%	92%	83%
Electricity	0%	6%	27%	38%	4%	5%	4%	1%	4%
Propane	9%	0%	0%	0%	0%	10%	6%	0%	6%
Fuel oil	6%	2%	1%	0%	0%	4%	4%	7%	4%
Dual fuel	0%	0%	0%	1%	<1%	0%	0%	<1%	<1%
District	0%	0%	0%	1%	0%	0%	0%	<1%	<1%
Mix in same bldg	0%	9%	0%	1%	3%	3%	3%	<1%	3%
Central system or individual system for each unit?									
Central	0%	19%	57%	44%	4%	15%	2%	85%	10%
Individual	100%	81%	41%	55%	96%	85%	98%	14%	90%
Mix in same bldg	0%	0%	2%	1%	0%	<1%	0%	1%	<1%
Type of heating system									
Forced air furnace	98%	71%	20%	18%	89%	77%	89%	27%	83%
Hydronic boiler	0%	10%	41%	40%	2%	9%	1%	54%	6%
Steam boiler	2%	3%	12%	4%	1%	5%	2%	18%	3%
Electric resistance	0%	5%	27%	31%	4%	4%	4%	1%	4%
Heat pump	0%	0%	0%	6%	0%	<1%	<1%	0%	<1%
Space heater	0%	4%	0%	0%	<1%	2%	1%	0%	1%
Radiant	0%	<1%	0%	0%	0%	<1%	<1%	0%	<1%
Mix in same bldg	0%	7%	0%	2%	3%	2%	3%	<1%	2%

[a]Excludes buildings where the landlord pays the heating bills for some units and tenants pay for others

FORCED AIR FURNACES

The study data suggest that there are about 350,000 forced air furnaces in Wisconsin rental buildings. Most of these furnaces are found in single-family rental homes and small multifamily buildings (Figure 3). Nonetheless, about 20 percent of larger buildings are heated with forced air furnaces, which are typically installed in utility closets. The average forced air furnace in a Wisconsin rental building has an input capacity of 45,000 Btu per hour. Approximately 14 percent of furnaces in rental buildings are high efficiency condensing models—a far lower saturation than that found in single-family, owner-occupied homes where more than half are high efficiency units.

HYDRONIC BOILER SYSTEMS

The second most common heating type found in rental buildings is the hydronic boiler heating system, with approximately 27,500 boilers in Wisconsin rental buildings. Although more prevalent in large apartment buildings, these systems are also found in smaller buildings and single-family rental units. The average Wisconsin boiler is 21 years old. Table 6 provides a breakdown of an estimate of the number of boilers in the state by firing rate and building size.

Hydronic systems with central pumps and zone valves are found in about 40 percent of buildings, typically in 20+ unit buildings. Only four percent of the buildings heated with a hydronic boiler system have outdoor air reset or cutout controls to increase the performance of the boiler.

TABLE 6. ESTIMATED STATEWIDE BOILERS BY FIRING RATE AND BUILDING SIZE

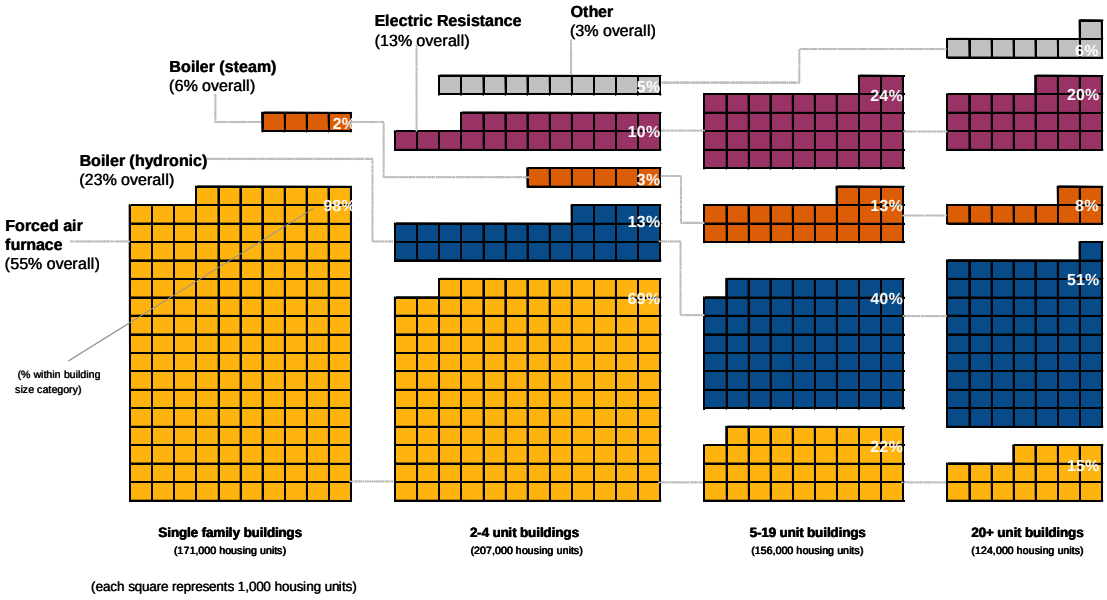
(HOUSING UNIT PROPORTIONS)	UNITS IN BUILDING			TOTAL
	2-4	5-19	20+	
# of boilers by firing rate (Btu/h)				
Less than 200,000	5,800	3,600	0	9,400
200,000 to 399,999	6,500	6,400	800	13,700
400,000 to 999,999	0	2,900	900	3,800
1,000,000 or more	0	200	400	600
Total	12,300	13,100	2,100	27,500

ELECTRIC RESISTANCE

Statewide, about 75,000 rental units (11%) employ electric resistance space heating. The study data suggest that there are about 10,000 rental buildings in the state with electric baseboard heat; about half of these are small multifamily buildings (2-4 units), and the other half are apartments in larger buildings. Electric baseboard heat is used in about one in five rental units in buildings with five or more units. The average building with electric baseboard heat is 24 years old.

A small proportion of buildings in the study had more than one type of space heating system. These generally involved small multifamily buildings with a mix of fuel-fired heating systems and electric resistance; however, two large apartment buildings in the study also had mixed heating system types.

FIGURE 3. RENTAL HOUSING UNITS BY HEATING SYSTEM TYPE AND BUILDING SIZE



Air Conditioning

Table 7 summarizes the characteristics of cooling systems in Wisconsin rental housing. About three-quarters of all rental units have some type of air conditioning system, a saturation rate that is comparable to that of single-family, owner-occupied homes in the state. However, the saturation of air conditioning varies substantially by building size: nearly all larger rental buildings have air conditioning, but more than a third of single-family rental units lack it (Figure 4).

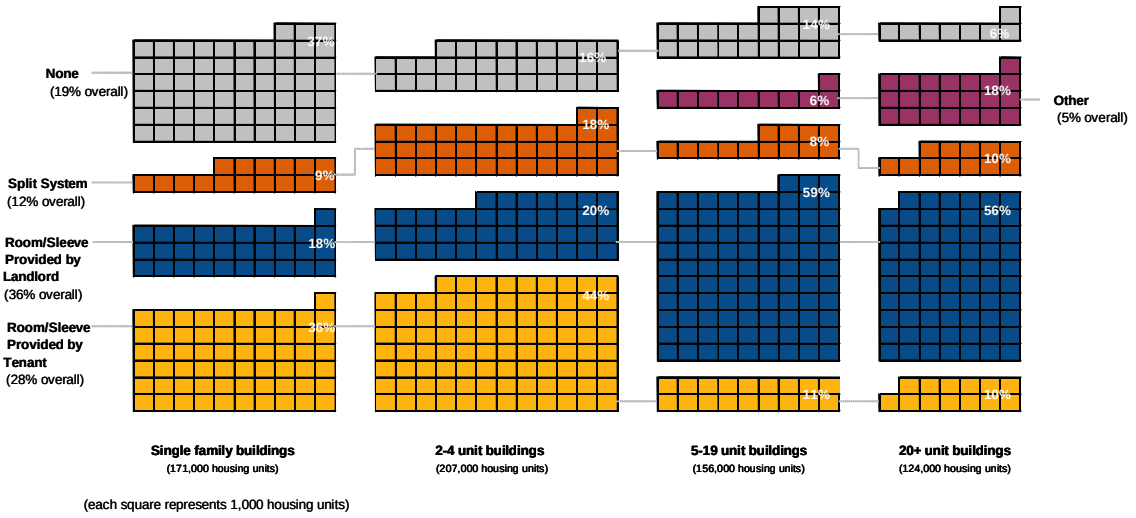
Window or sleeve room AC units are the dominant type of air conditioning system in rental buildings; these constitute more than 80 percent of the installed systems, and are found in more than 70 percent of rental buildings with air conditioning. In smaller buildings (1 – 4 units), these are mostly window units provided by the tenant; larger buildings (20+ units) are more likely to have landlord-provided sleeve units.

Since air conditioners are typically connected to the tenant's electric meter, tenants are overwhelmingly directly responsible for paying the costs of cooling their rental unit.

TABLE 7. COOLING CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		COOLING PAID BY TENANT?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	YES	NO	
Who pays the cooling?									
Tenants	95	93	95	93	99	95			94
Landlord	5	7	5	7	<1	5			6
Central system or individual system for each unit?									
Central	0	0	2	2	0	<1	0	3	<1
Individual	63	86	83	89	70	73	99+	95	72
Mix in same bldg	0	0	2	4	0	<1	<1	2	<1
None	37	14	14	6	30	26			28
Type of cooling system									
Room	54	65	72	63	67	51	80	95	58
Split system	9	18	5	10	0	21	13	2	12
GSHP	0	0	0	1	0	<1	<1	0	<1
Chiller	0	0	0	2	0	<1	0	<1	<1
ASHP	0	0	0	6	0	<1	<1	0	<1
Other	0	4	9	12	3	1	2	2	2
None	37	14	14	6	30	27	5	0	28
Average size									
Room									
Capacity, Btuh	7,300	7,800	9,800	10,100	7,700	10,700	8,600	10,700	8,700
EER	8.9	8.7	8.6	8.5	8.7	8.8	8.6	9.2	8.7
Split system									
Capacity, tons	—	1.6	2.9	2.7	—	2.1	2.1	2.0	2.1
EER	—	10.0	9.4	9.1	—	9.5	9.5	9.7	9.5

FIGURE 4. RENTAL HOUSING UNITS BY AIR CONDITIONING TYPE AND BUILDING SIZE



Water Heating

Table 8 summarizes the characteristics of domestic hot water (DHW) heating systems in Wisconsin rental housing. Central hot water heating systems serve the majority of rental units in larger buildings, but smaller buildings overwhelmingly have individual units.

Overall, natural gas is the fuel source for hot water for nearly three-quarters of all buildings. However, a significant minority of buildings of all sizes have electric water heaters. In all but the largest buildings, these are conventional storage-tank water heaters. About a quarter of large buildings (20+ units) use space heating boilers to indirectly provide domestic hot water.

About one in six buildings with natural gas space heating have electric water heating. These are most likely to be single-family rental homes or 2-4 unit rental buildings.

The measured temperature of hot water delivered to the kitchen faucet averaged 126 degrees overall, and was relatively consistent across building sizes. In contrast, measured showerhead flow rates indicated somewhat higher flows in larger buildings compared to smaller ones.

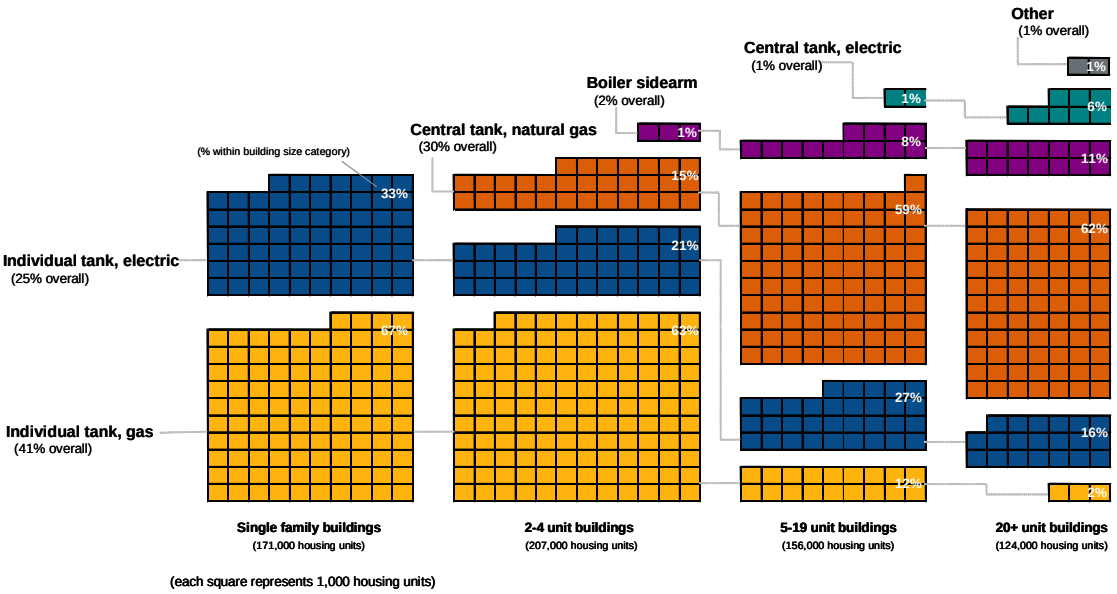
The study collected information on the presence of tank wrap insulation and the percentage of pipe wrap insulation. Additional tank wrap insulation is found in about a quarter of small multifamily buildings (2-4 units), but is less common (or rare) among other building sizes. Hot water pipe insulation is more likely to be found among large (20+ unit) buildings than in other building size categories.

TABLE 8. WATER HEATING CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		
	1	2-4	5-19	20+	YES	NO	ALL BLDGS
Who pays for heating?							
tenant	97	87	41	31	97	87	89
landlord	3	12	59	69	3	12	10
mix in same building	0	1	0	0	0	1	<1
Central vs individual (%)							
central system	0	13	59	69	5	12	8
individual	100	85	41	31	95	87	91
mix	0	2	0	0	0	1	1
Type (%)							
conventional	100	99	99	71	77	81	81
sidearm	0	1	0	27	22	17	17
other	0	0	1	2	2	2	2
Fuel (%)							
natural gas	67	79	68	59	65	72	71
electric	33	16	31	40	31	27	28
other	0	0	1	1	<1	<1	<1
mix	0	5	0	0	3	1	2
Average size							
Individual							
Tank size, gallons	55	46	51	55	53	50	51
capacity, Btuh	27,300	30,400	35,800	28,800	36,000	30,000	31,200
Central							
Tank size, gallons	0	50	50	56	55	55	55
capacity, Btuh	0	31,100	37,900	30,900	35,000	31,200	32,100
Insulation							
% with tank wrap	11	26	11	1	7	6	6
fraction of basement piping insulated (%)							
none	67	60	66	70	43	74	68
less than half	11	21	12	0	11	3	4
more than half	0	5	5	4	0	4	3
all	17	15	17	26	46	18	23
Other							
Avg. delivered water temp.(°F)	129	126	126	126	121	127	126
(% >135F)	25	13	37	17	17	29	22
Showerhead flow rate (gpm)	2.3	2.5	2.5	2.7	2.5	2.6	2.7
(% >2.5 gpm)[a]	49	80	68	93	65	59	60

[a]Percent of buildings with at least one showerhead that measured above 2.5 gpm.

FIGURE 5. RENTAL HOUSING UNITS BY WATER HEATER TYPE AND BUILDING SIZE



Lighting

The study included a survey of lighting in each building. Auditors gathered data on the type, location, and wattage of lighting in common areas as well as in sampled rental units. Table 9, Table 10, and Table 11 summarize the lighting characteristics for the buildings in the study – in terms of common area lighting, exit lighting, and in-unit lighting.

Common areas generally offer good opportunities for energy efficiency upgrades due to long hours of operation. Nearly all buildings with five or more units have common areas and about half of the buildings with 2-4 units have them. The bulb type in common areas varies greatly according to the number of units in the building. Only five percent of the fixtures in buildings with 20 or more units still have incandescent bulbs whereas half the fixtures in buildings with 5-19 units and more than four of five fixtures in buildings with 2-4 units are incandescent. Fluorescent fixtures are evenly distributed between tube fluorescents, pin-based CFLs, and screw-based CFLs, with about two-thirds of common-area lighting supplied by ceiling fixtures.

Exit lighting also offers good energy efficiency upgrade potential if the fixture is still incandescent or fluorescent, since these can be upgraded to a more efficient LED type. Since exit signs are required in buildings with common areas, most opportunities are in large rental unit buildings. However, in buildings with 20 or more rental units, almost half of the exit signs are LED whereas only about one in four signs are LED in smaller unit buildings. In fact, almost half of exit signs in buildings with 2-4 units are still incandescent. Low-income buildings are twice as likely to have incandescent exit signs as non-low income buildings.

In-unit lighting is dominantly incandescent. Almost nine of every ten bulbs in rental units are still incandescent. There is an average of about 11 fixtures per rental unit and the average incandescent bulb

wattage is more than 60 watts. Screw-based CFLs have only penetrated about 2% of all fixtures in rental units. Ceiling fixtures are most prevalent in rental units (60% of fixtures) followed by wall fixtures then table lamps.

TABLE 9. COMMON AREA LIGHTING CHARACTERISTICS (EXCLUDING EXIT LIGHTS)

	UNITS IN BUILDING				LOW-INCOME BUILDING?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	
Buildings with common area lighting	0	55	97	100	6	72	78
Average number of fixtures per building	0	7	19	70	22	12	13
Fixture type (%)							
Wall		25	31	37	38	30	30
Ceiling		71	61	59	59	66	65
Other		4	8	4	3	4	4
Bulb type (%)							
Incandescent	—	82	51	5	54	49	50
Fluorescent fixture	—	5	18	27	24	20	20
Screw-based CFL	—	6	13	26	2	9	9
Pin-based CFL	—	5	12	37	16	16	16
Other	—	2	6	5	4	6	5
Average bulb wattage							
Incandescent	—	70	60	60	61	65	64
Fluorescent fixture	—	33	29	36	36	32	33
Screw-based CFL	—	17	16	23	20	16	16
Pin-based CFL	—	13	15	13	13	14	13

TABLE 10. EXIT LIGHT CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	
Average number of exit lights per building		2	3	16	4	7	7
Bulb type (%)							
Incandescent	-	47	33	10	40	20	23
Fluorescent	-	18	34	37	43	36	37
LED	-	23	29	46	10	39	35
Other	-	12	4	7	7	5	5

TABLE 11. IN-UNIT LIGHTING CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	
Average number of fixtures							
Per unit	15	11	12	9	10	11	11
Fixture Type (%)							
Ceiling	67	64	55	48	58	60	60
Table lamp	9	15	14	21	13	14	14
Floor lamp	5	5	8	7	3	6	6
Wall	17	13	22	22	18	18	18
Other	3	3	1	2	8	2	2
Bulb type (%)							
Incandescent	81	88	95	89	91	87	88
Fluorescent fixture	14	4	3	5	6	7	7
Screw-based CFL	2	3	0.3	2	2	2	2
Pin-based CFL	2	4	0.5	2	2	3	2
other	1	1	1	2	0	1	1
Average bulb wattage							
Incandescent	66	62	60	63	64	62	63
Fluorescent fixture	38	40	32	30	34	37	37
Screw-based CFL	20	17	32	27	26	20	20
Pin-based CFL	16	30	21	17	16	29	28

Appliances

REFRIGERATOR & FREEZER CHARACTERISTICS

The study collected average age and temperature of the refrigerator as well as the type of freezer. The vast majority of refrigerators are top-freezer style. About 85 percent are auto-defrost.[4] There is little variability in refrigerator interior temperature across building size, but refrigerators in larger buildings tend to be somewhat newer. Although a quarter of refrigerators in Wisconsin rental housing are provided by tenants, these are nearly all in single-family rental homes and duplexes.

TABLE 12. REFRIGERATION CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	
Who provides? (% of units)							
Tenant	53	33	5	0	42	17	25
Landlord	47	64	95	100	58	83	75
Size (ft^3)	16.8	16.2	16.2	14.9	16.5	15.9	16.1
Age (years)	11	10	9	8	8	10	9
Interior Temperature (F)	39	39	38	38	38	38	38
Type (% of units)							
Top-Freezer	91	92	98	97	93	98	95
Side-by-Side	9	7	2	2	7	2	5
Bottom-Freezer	0	0	<1	0	<1	0	<1
Dorm	0	0	0	1	0	<1	<1
Stand-alone freezer in building? (% yes)	25	10	8	5	10	26	19

By and large, there is one refrigerator per dwelling unit, which translates into about 660,000 rental-sector refrigerators in the state. The on-site audits also revealed a small number of refrigerators in common areas. This translates to about 1,500 common-area refrigerators statewide.

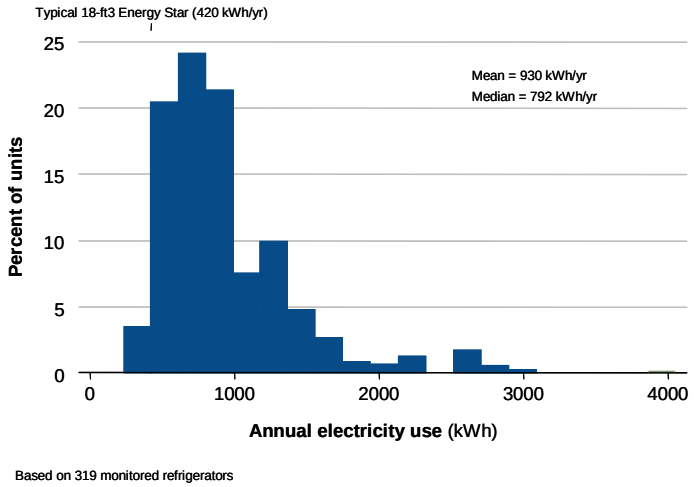
About a quarter of single-family rental homes were found to have stand-alone freezers, and some freezers were even found in larger apartment buildings. Overall the data suggest that there are about 55,000 stand-alone freezers in Wisconsin rental housing, mostly in single-family homes and duplexes. About two-thirds of these are chest type freezers, and one-third are upright models.

[4] Though defrost type was only noted for about half of the refrigerators recorded.

Monitored Usage

A part of the on-site data collection protocol was to conduct short-term metering of refrigerator (and occasionally, freezer) electricity consumption in apartments and common areas. The protocol called for installing a meter on the refrigerator in each apartment for which in-unit data was being collected and to collect electricity consumption data for a minimum of two hours. In practice, not all refrigerators could be moved to install the meters, and some data were lost due to incorrect installation and other errors. Nonetheless, we recovered usable data for 319 refrigerators, of which all but four were in apartment units.

Figure 6. Distribution of refrigerator electricity usage.

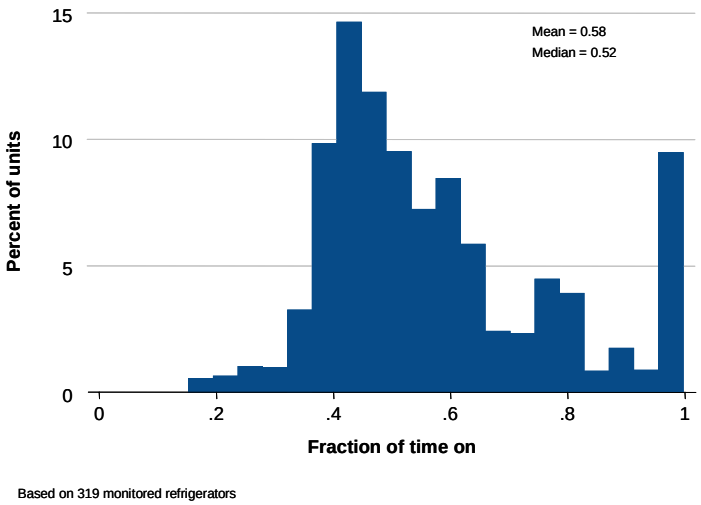


We used these data to calculate average running wattage and duty cycle, as well as to estimate the annual electricity consumption of the units (see Appendix E).

The results indicate that the typical refrigerator in a Wisconsin rental unit uses about 800 kWh of electricity per year, and more than 90 percent of units use more than a typical new 18-cubic foot ENERGY STAR labeled unit (Figure 6).

A minority of refrigerators use substantially more electricity than average; these are mostly older units that run an inordinate amount of time, which generally indicates that the unit is not functioning properly. While the majority of refrigerators run about half the time (with average on- and off-times of about 16 and 20 minutes, respectively), the monitoring data indicate that about 12 percent of refrigerators run 90 percent of the time or more (Figure 7).

Figure 7. Distribution of refrigerator duty cycle.



Older refrigerators use considerably more electricity than newer ones. We found that each additional year of age corresponds to about an additional 20 kWh/year of electricity use. Some older refrigerators also have anti-sweat devices that consume up to 40 watts of electricity even when the compressor is not running. Nearly three quarters of rental-sector refrigerators consume some power all the time, though this off-cycle consumption adds less than three percent to total electricity consumption.

Automatic-defrost models use additional electricity for defrost cycles. Analysis based on 44 units that underwent a defrost cycle during monitoring suggests that automatic defrost typically adds about 50 kWh to the annual electricity use of a refrigerator, or about seven percent.

Only 21 of the 319 refrigerators monitored for the project were tenant-owned units. Though electricity use was slightly (7 percent) less for these units, the difference is not statistically significant.

LAUNDRY

The study collected information on common versus individual laundry rooms, fuel type of the dryer(s), and the amount of usage charge (Table 13). As one would expect, the larger the number of rental units in the building, the more likely it is that the building will have a common laundry room. In fact, only six percent of buildings over 20 units have individual laundry facilities.

Electric dryers are used in about 85% of all rental buildings. This figure is consistent across all size of buildings categories; however, it is interesting to note that low-income buildings are almost four times as likely to have natural gas dryers as non-low income buildings. A large majority of common laundry rooms in buildings with five or more units charge for use of the laundry facilities. Overall, about half of all rental buildings charge for laundry equipment use. In low-income buildings, this percentage decreases to only about one-third versus almost two-thirds in non-low income buildings.

TABLE 13. LAUNDRY CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		
	1	2-4	5-19	20+	YES	NO	ALL BLDGS
Laundry							
% Common	0	24	76	94	18	28	24
% Individual	100	76	24	6	82	72	76
Dryer Fuel							
% Electric	84	85	89	79	69	92	85
% Natural Gas	16	15	11	21	31	8	15
Common Dryers							
% with usage charge	0	14	92	73	31	65	51
Average $ charged	--	0.78	0.79	0.83	0.67	0.80	0.78
% with no usage charge	100	86	8	27	80	35	49
Common Washers							
% with usage charge	6	16	90	79	23	61	43
$ charged	0.75	1.00	0.88	0.92	0.84	0.93	0.92
% with no usage charge	94	84	10	21	77	39	57

RANGE / OVEN CHARACTERISTICS

The study collected information on the fuel type of ranges / ovens and measured carbon monoxide (CO) levels as well. In cases where CO exceeded 50 ppm, the landlord or property manager signed a release stating that they knew of the high concentration of CO and agreed to have it inspected and repaired.

Gas and electric ranges are equally common in small buildings, but electric ranges make up 75 percent or more of units in 5+ unit buildings (Table 14). A substantial proportion of gas ranges across all building sizes were found to produce more than 50 ppm of carbon monoxide.

TABLE 14. RANGE AND OVEN CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		
	1	2-4	5-19	20+	YES	NO	ALL BLDGS
Fuel Type (%)							
Electric	50	49	75	81	50	69	62
Gas[a]	50	51	25	19	50	30	38
Range CO level (%)							
0-49 ppm	41	80	69	58	50	75	66
50+ ppm	59	20	31	42	50	25	34
Oven CO level (%)							
0-49 ppm	100	100	100	100	100	100	100
50+ ppm	0	0	0	0	0	0	0

AUTOMATIC DISHWASHERS

The tenant survey asked about automatic dishwashers. Based on these self-reported data, larger buildings are more likely to have automatic dishwashers in apartments than smaller buildings (Table 15), though the number of loads run per week is smaller for tenants of larger buildings.

TABLE 15. AUTOMATIC DISHWASHER CHARACTERISTICS

	UNITS IN BUILDING				LOW-INCOME HOUSEHOLD?		
	1	2-4	5-19	20+	YES	NO	ALL BLDGS
None	59	79	48	47	76	47	60
Built-in	31	10	50	52	23	42	33
Portable (landlord provided)	10	11	1	1	1	10	6
(tenant provided)	0	0	1	<1	<1	<1	<1
Loads per week	3.6	3.0	2.8	2.2	3.2	2.9	2.9
(from tenant survey, n=727)							

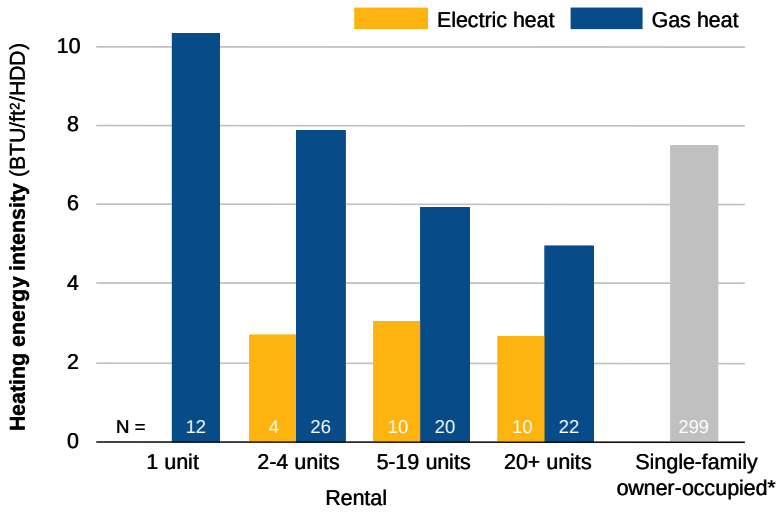
ENERGY USE

As part of the study, we obtained permission from landlords to access utility usage histories for master-metered accounts for the sampled building, as well as permission from respondents to the tenant survey to obtain histories for tenant-paid accounts[5]. We were able to obtain usable natural gas consumption data for 60 percent of the 155 buildings in the study with natural gas service, and usable electricity data for 68 percent of the 180 buildings, representing a total of 145 separate gas accounts, and more than 1,600 electricity accounts.

To conduct the analysis, we statistically analyzed each account to separate space-heating and space-cooling usage from consumption that is not weather-sensitive, as well as to normalize the data to typical weather conditions. (Appendix C provides the details about this procedure.) We then aggregated these account-level results to the building level. Note that in most cases, this required extrapolating the limited number of tenant accounts to which we had access to all units in the building.

Table 16 and Table 17 break out these data in various ways. Though sample sizes are small when broken out by building size, in general the data indicate that larger buildings use less heating energy per square foot than smaller buildings (Figure 8). This is likely because large buildings have less exposed surface area for heat loss per square foot of floor space. Apartments and family size tend also to be smaller in large buildings, so non-space conditioning energy use per unit tends to be lower as well for larger buildings.

FIGURE 8. HEATING ENERGY INTENSITY BY BUILDING SIZE AND FUEL



*Source: "Energy and Housing", ECW 2000
(includes all fuels; excludes basement areas)

[5] One utility provided data for all accounts in the building.

TABLE 16. NATURAL GAS USAGE

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	YES	NO	
Total building use (therms/yr)									
Space heating[a]	900	1,600	3,900	12,900	1,300	1,500	1,200	4,200	1,400
Other[a]	270	560	1,600	5,700	590	570	410	1,800	550
Total	1,100	2,000	4,900	15,200	1,600	2,100	1,500	5,900	1,800
	(200)	(300)	(800)	(2,400)	(500)	(300)	(200)	(1,000)	(200)
Total building use per dwelling unit (therms/yr)									
Space heating[a]	900	680	450	290	890	720	810	490	780
Other[a]	270	240	170	140	350	210	240	200	250
Total	1,100	860	560	360	1,030	910	980	680	970
	(200)	(130)	(100)	(40)	(300)	(80)	(116)	(190)	(100)
Overall Heating energy intensity (Btu/ft^2/HDD)[b]	10.3	7.9	5.9	4.9	10.6	7.8	9.4	7.2	9.2
	(1.0)	(0.9)	(0.5)	(0.6)	(1.7)	(0.6)	(0.7)	(0.5)	(0.7)
Tenant-paid use per dwelling unit (therms/yr)[c]	1,100	830	330	190	1,030	910	1,010	140	970
	(200)	(140)	(80)	(60)	(300)	(80)	(120)	(180)	(110)
Landlord-paid use per dwelling unit (therms/yr)[d]	—	510	810	340	360	620	170	770	580
		(110)	(260)	(50)	(70)	(12)	(50)	(120)	(90)
Study sample	12	30	22	26	19	68	54	36	90

Numbers in parentheses are standard errors.
[a]excludes buildings without this end use.
[b]for buildings with gas heat (n=80).
[c]excludes buildings without tenant-paid natural gas.
[d]excludes buildings without landlord-paid natural gas.

TABLE 17. ELECTRICITY USAGE

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		ALL BLDGS
	1	2-4	5-19	20+	YES	NO	YES	NO	
Total building use (MWh/yr)									
Space heating[a]	—	8.5	37.6	117	15.9	44.8	29.0	—	30.0
Space cooling[b]	0.54	1.4	3.1	16.0	1.1	1.7	1.1	4.0	1.4
Other	9.1	11.8	35.5	175	11.2	17.6	12.9	35.9	15.3
Total	9.5	13.8	48.2	241	13.8	22.0	16.0	40.0	18.5
	(1.7)	(1.8)	(7.8)	(21.8)	(3.2)	(3.7)	(1.9)	(9.0)	(2.0)
Total building use per dwelling unit (kWh/yr)									
Space heating[a]	—	3,100	5,000	4,700	3,100	4,900	3,900	—	4,000
Space cooling[b]	540	590	340	430	600	490	560	330	540
Other	9,100	4,500	4,200	4,400	6,100	7,200	7,300	3,500	6,900
Total	9,500	5,500	5,800	6,900	7,000	7,800	8,000	3,800	7,600
	(1,700)	(500)	(1,000)	(600)	(1,200)	(1,500)	(1,000)	(400)	(1,000)
Overall Heating energy intensity (Btu/ft^2/HDD)[c]	—	2.7 (0.9)	3.0 (0.3)	2.7 (0.7)	3.1 (1.0)	2.7 (0.4)	2.9 (0.6)	—	2.9 (0.6)
Tenant-paid use per dwelling unit (kWh/yr)[d]	9,500 (1,700)	5,600 (500)	5,700 (1,100)	5,600 (500)	7,200 (1,200)	7,700 (1,500)	8,100 (1,100)	3,100 (400)	7,600 (1,000)
Landlord-paid use per dwelling unit (kWh/yr)[e]	—	1,400 (400)	1,500 (300)	2,300 (500)	2,200 (800)	1,300 (200)	1,600 (400)	1,400 (300)	1,500 (200)
Study sample	12	33	42	32	33	83	73	45	119

Numbers in parentheses are standard errors.

[a]excludes buildings with non-electric space heating.

[b]excludes buildings without air conditioning, and those without detectable space-cooling usage at the building level. Overall, 13 out of 105 buildings with air conditioning had no detectable usage.

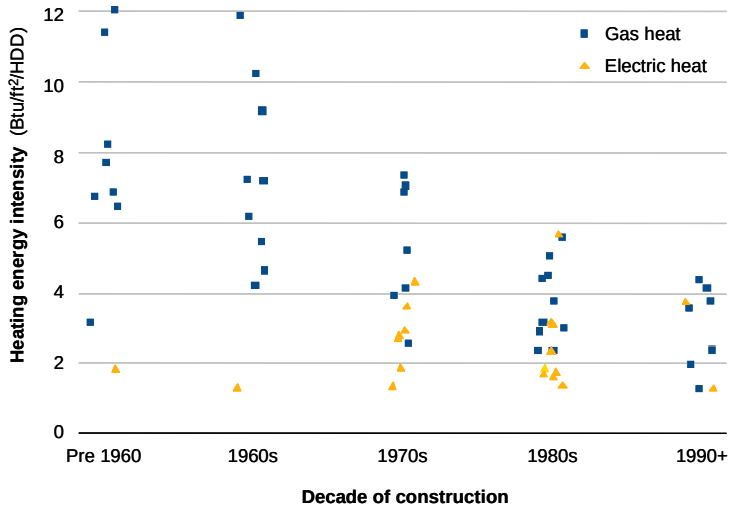
[c]for electrically heated buildings (n=24)

[d]excludes buildings without tenant-paid electricity.

[e]excludes buildings without landlord-paid electricity.

Heating energy intensity is also a function of building age. As Figure 9 shows, recently built buildings are far more efficient than those constructed before the 1970s, and the highest observed heating energy intensity has declined significantly over time. This is no doubt due in large part to state energy codes that first came into being around 1980.

FIGURE 9. HEATING ENERGY INTENSITY BY BUILDING VINTAGE, FOR 5+UNIT BUILDINGS.

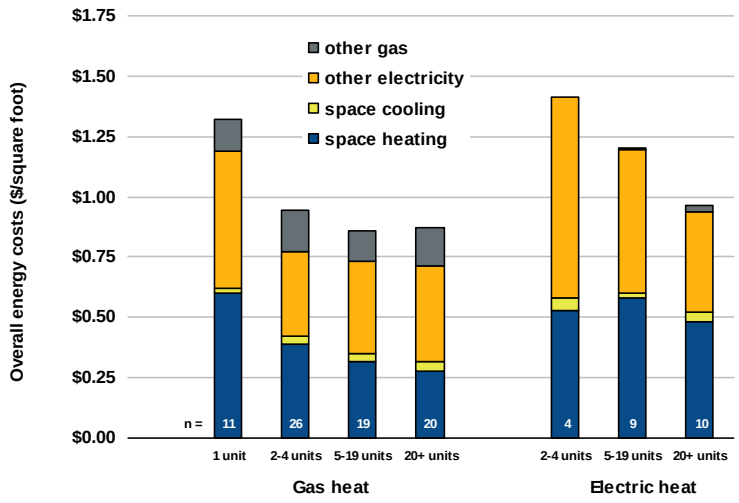


5+ unit buildings
Points perturbed slightly horizontally or clarity

The 24 electrically-heated buildings for which we were able to obtain usage histories do not exhibit these trends, and appear to be considerably more efficient in terms of heating energy intensity. In general, electrically-heated buildings in our sample tend to be newer than gas-heated buildings, and—from the limited insulation observations made, appear to be somewhat better insulated.

Nonetheless, the high cost of electricity means that these buildings still cost somewhat more to operate than gas-heated buildings (Figure 10). This is also a reflection of the fact that electrically-heated buildings also tend to have electric water heating and appliances, as well.

FIGURE 10. ANNUAL UTILITY COST PER SQUARE FOOT



In aggregate terms, the utility data available to us suggest that rental buildings use about 3.2 GWh of electricity annually. This represents about 20 percent of electricity used in residential buildings, and five percent of all Wisconsin electricity consumption.[6] About 85 percent of this electricity is paid for directly by tenants, and the vast majority (about 90 percent) is for uses other than heating and cooling buildings. Moreover, about 70 percent of electricity use in the rental sector

[6] Based on 67,872 million kWh of electricity consumed in Wisconsin in 2002. Source: *2003 Energy Statistics*, Wisconsin Department of Administration, page 46 (www.doa.state.wi.us).

occurs in buildings with fewer than five units—and nearly half is consumed in single-family rental homes.

For natural gas, we estimate that rental buildings in Wisconsin use about 330 million therms annually, representing about 25 percent of the natural gas in all residential buildings, and nine percent of all non-utility natural gas use in the state.[7] Tenants directly pay for about 70 percent of this consumption, about three-quarters of which is used for space heating purposes. As with electricity, about 70 percent of natural gas in the rental sector is consumed in buildings with fewer than five units.

ENERGY EFFICIENCY OPPORTUNITIES

To examine the potential for energy savings in Wisconsin rental buildings, we defined a number of energy efficiency opportunities, and then looked at how prevalent these opportunities are in our sample of buildings. These opportunities, which are described in more detail in the following sections, include energy efficiency measures typically recommended for rental buildings, though it is by no means an exhaustive list.

For each measure, we defined criteria as to whether the measure was applicable for each building in the sample based on the data collected during the on-site audits. We then estimated the cost and energy savings associated with the measure, and screened these for the length of payback. For most of the measures on the list, the savings and cost are customized for each building; for example, our estimates of the energy savings and the cost of wall insulation are based on the wall and ceiling area needing to be insulated. To estimate the energy savings for measures that affect space heating and cooling, we modeled each building in REM/Design with and without the measure, and took the difference in estimated energy use as the savings due to incorporating the measure. We used other recognized approaches (documented below) to estimate savings for measures that were not amenable to assessment using REM/Design. The assumptions and methods we used are documented in Appendix D.

Note that we did not attempt to compute *interacted* estimates of savings from the opportunities we identified. For example, the energy cost savings from both replacing showerheads and switching from electric to natural gas water heat are less than the sum of implementing each of these measures individually. Our purpose was to provide a relative sense of where the opportunities for efficiency improvements in rental housing lie, rather than to estimate the total potential savings in the housing stock.

Figure 11 shows the percent of buildings with energy efficiency opportunities for 2-, 5- and 10-year payback periods.

Lighting—particularly in-unit lighting—and water heating measures dominate the incidence of opportunities, particularly for short payback periods.

[7] Based on 3,668 million therms of natural gas consumed in Wisconsin in 2002. Source: *2003 Energy Statistics*, page 29.

Of course, some measures save significantly more energy than others. When looked at in the aggregate (Figure 12), lighting and water heating improvements still dominate the shorter payback opportunities, but for longer payback periods, other measures offer as much or more in the way total cost savings. (Again, these breakouts are based on non-interacted savings estimates.)

It is also noteworthy that while single-family and small multifamily buildings make up about half of the rental sector housing units, they account for 70 percent or more of the aggregate energy cost savings opportunities. This suggests that there are relatively more opportunities among these buildings.

It is also important in this sector to consider *who* gets the benefits of any energy efficiency improvements that might be undertaken. As Figure 13 shows, tenants directly reap most of the benefits of opportunities in smaller buildings; heating and water heating measures in larger buildings are most likely to provide direct utility-bill savings for landlords.

FIGURE 11. PERCENT OF BUILDINGS WITH ENERGY EFFICIENCY OPPORTUNITIES (2-, 5-, AND 10-YEAR PAYBACK), BY MEASURE AND BUILDING SIZE CATEGORY

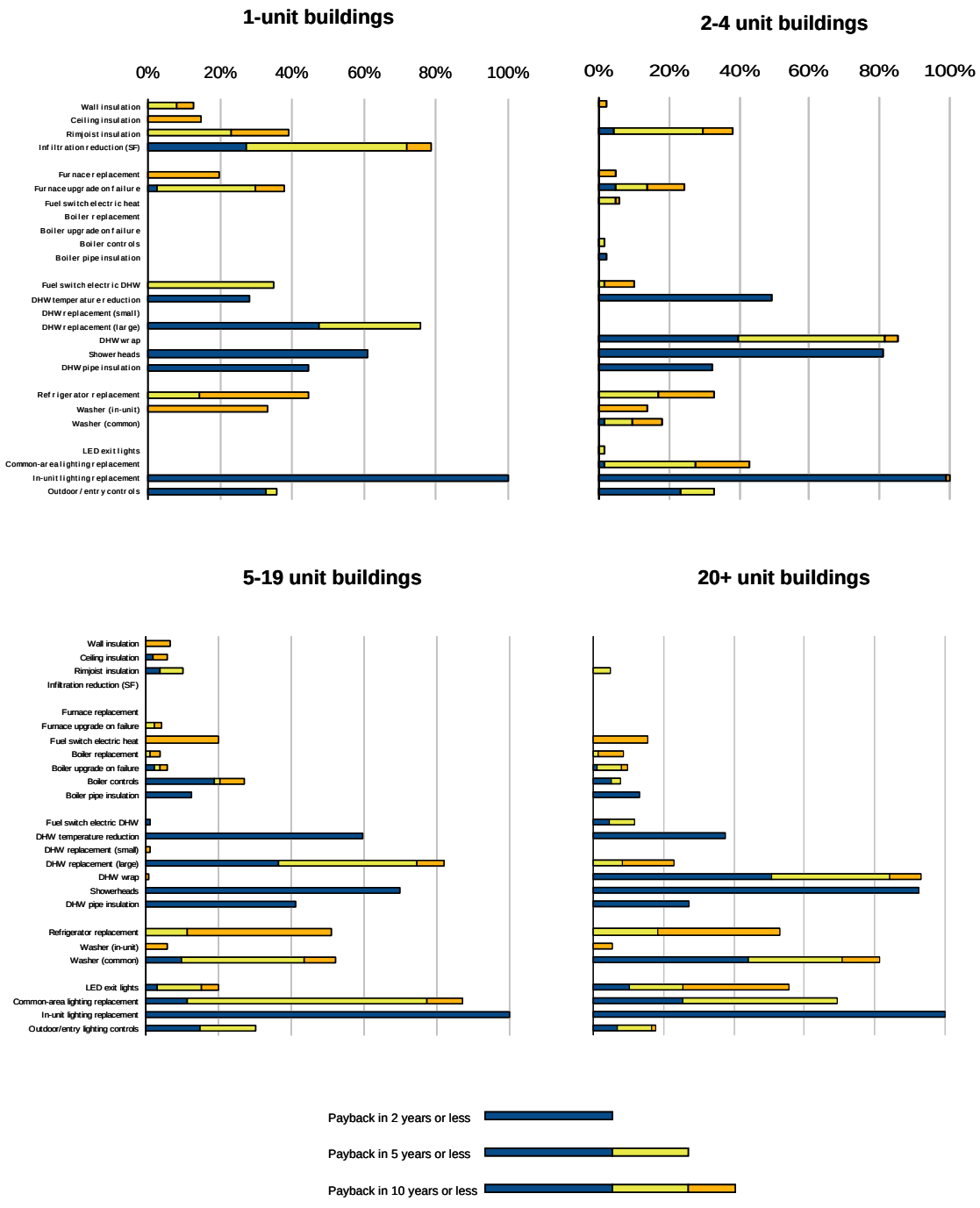


FIGURE 12. AGGREGATE ENERGY COST SAVINGS OPPORTUNITIES, BY PAYBACK, BUILDING SIZE, AND END-USE

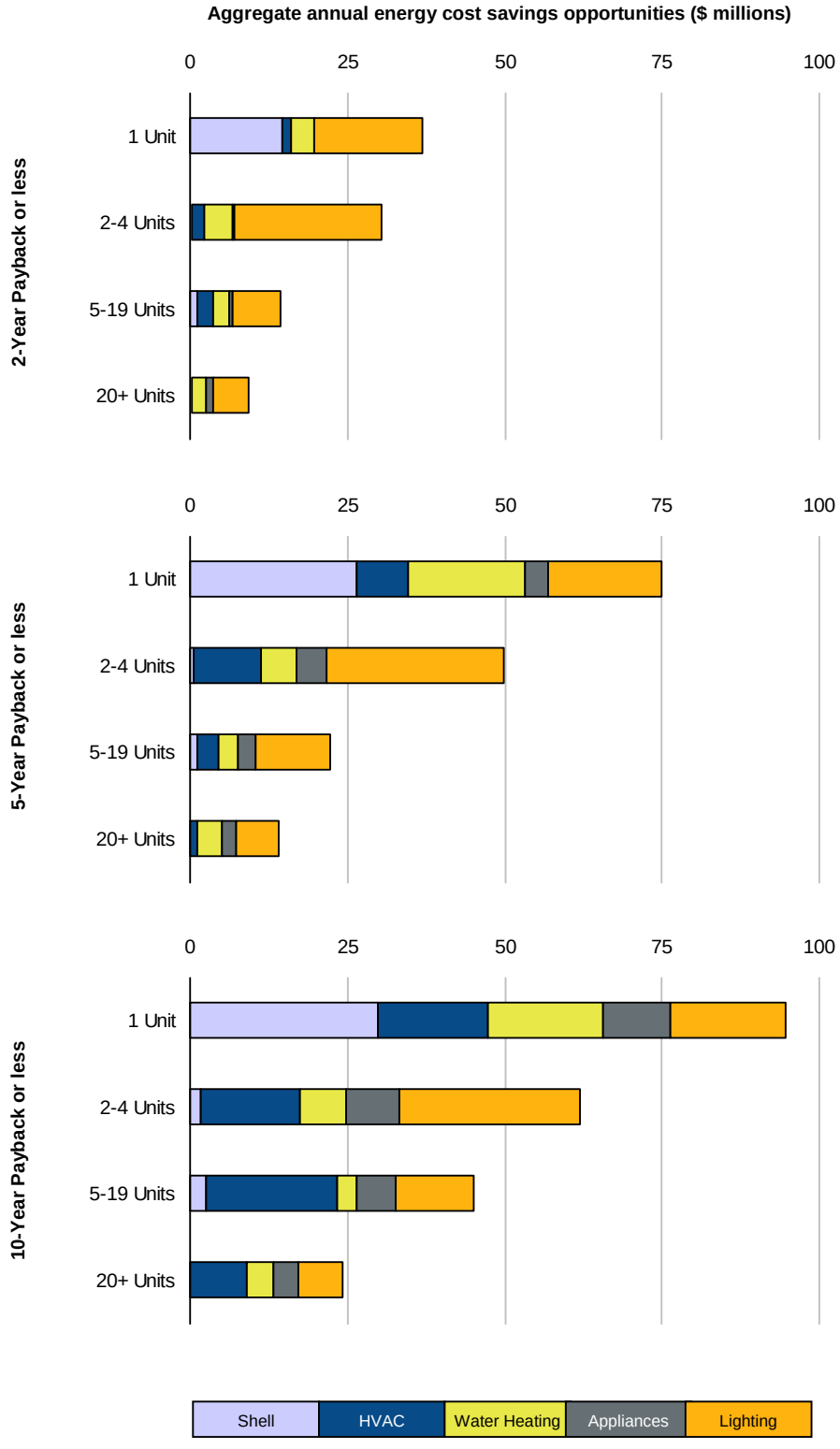
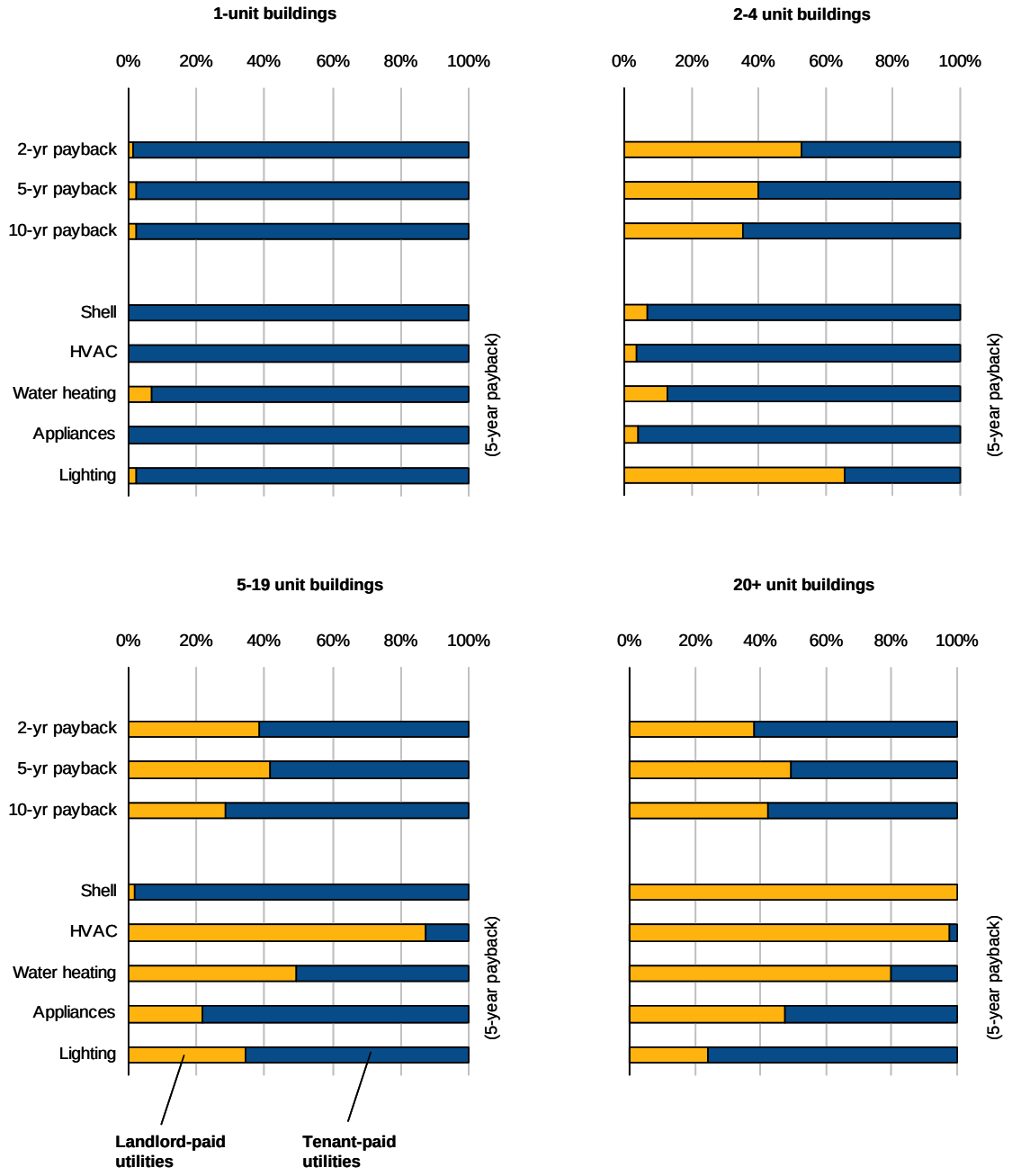


FIGURE 13. BREAKDOWN OF AGGREGATE SAVINGS BETWEEN LANDLORD- AND TENANT-PAID UTILITIES, BY BUILDING SIZE, PAYBACK PERIOD AND END-USE.



In the following subsections, we cover in more detail the various opportunities for energy efficiency improvements.

Building envelope (shell) measures

Reducing the amount of energy used to heat and cool a building can be achieved by adding insulation and reducing air leakage. We considered several building envelope improvements, including adding insulation to the ceiling, walls, and rim-joist, and reducing the natural infiltration rate of single-family rental units. (The study did not investigate air leakage and leakage-reduction opportunities in multifamily buildings.)

Because most buildings were found to be substantially insulated in terms of ceilings and walls, the fraction of buildings with insulation opportunities is relatively small, and mainly exists among single-family rental homes under longer payback periods.

The high measured air leakage among single-family rental homes represents significant savings opportunities. These homes averaged nearly twice the air leakage as owner-occupied homes in Wisconsin.

TABLE 18. BUILDING SHELL OPPORTUNITIES

	PERCENT OF BUILDINGS WITH OPPORTUNITY							AVERAGE SAVINGS AND COST PER AFFECTED DWELLING UNIT[b]	
	UNITS IN BUILDING				LOW-INCOME BUILDING?		PERCENT OF UNITS[a]		
	1	2-4	5-19	20+	YES	NO		SAVINGS	COST
2-year payback									
Wall insulation	0	0	0	0	0	0	0	—	—
Ceiling insulation	0	0	2	0	0	0	<1	$335	$429
Rimjoist insulation	0	4	4	0	3	0	2	$23	$23
Infilt. reduction[c]	27	—	—	—	—	—	—	$312	$317
5-year payback									
Wall insulation	8	0	0	0	0	10	2	$415	$1,255
Ceiling insulation	0	0	2	0	<1	0	<1	$335	$429
Rimjoist insulation	23	30	10	5	24	19	18	$11	$31
Infilt. reduction[c]	72	—	—	—	—	—	—	$164	$243
10-year payback									
Wall insulation	13	2	7	0	7	12	6	$219	$957
Ceiling insulation	15	0	6	0	9	13	6	$87	$474
Rimjoist insulation	39	38	10	5	43	26	25	$10	$34
Infilt. reduction[c]	78	—	—	—	—	—	—	$152	$235

[a]Represents the percent of statewide rental housing units with cost-effective savings opportunity. For shell measures, all units for each building with a shell opportunity are included.
[b]Average savings and cost are per dwelling unit affected by the measure. For shell measures, all units for each building with a shell opportunity are included.
[c]Opportunities for infiltration reduction were only examined for single-family buildings.

Heating System Measures

The rental unit heating system is obviously a significant energy user and is an important component of the savings potential assessment process. Savings from system replacement can exceed 25 percent, but the relatively high capital expense makes many replacements cost effective only on failure. In addition, boiler controls and pipe insulation offer opportunities for savings from existing hydronic systems.

We considered several heating system replacement options, all of which are based on replacing conventional atmospheric heating systems (except electric baseboard) with high efficiency condensing models:

1. Replacement before failure — in which the full cost of the heating system must be justified by the energy savings from the replacement.
2. Upgrade on failure — in which only the incremental cost to upgrade to a high efficiency condensing system needs to be justified by the energy savings that result from the upgrade.
3. Replacing electric baseboard systems with natural gas furnaces (fuel switch) — the relatively high cost of electricity for space heating offers substantial operating costs savings, but the savings need to justify the additional cost to add distribution ductwork.

We found little potential for heating system replacement with less than a five year payback (Table 19). However, for both boiler replacements in buildings with 5 or more units, and furnaces in 1-4 unit buildings, opportunities in the 5 to 10 year payback range do exist. These are nearly all in the form of efficiency upgrades on failure: we found that the savings from heating system replacement rarely justifies the full cost of a new heating system. Insuring replacement with an energy efficient option upon failure is an important key to improving the overall efficiency of the rental market. This implies that working with contractors who are on the front lines of such replacement is an important element of realizing the savings potential from these replacements.

TABLE 19. HEATING SYSTEM OPPORTUNITIES

	PERCENT OF BUILDINGS WITH OPPORTUNITY							AVERAGE SAVINGS AND COST PER AFFECTED DWELLING UNIT[b]	
	UNITS IN BUILDING				LOW-INCOME BUILDING?		PERCENT OF UNITS[a]		
	1	2-4	5-19	20+	YES	NO		SAVINGS	COST
2-year payback									
Furnace replacement	0	0	0	0	0	0	0	—	—
Furnace upgrade on failure	3	5	0	0	3	4	2	$287	$500
Fuel switch electric heat	0	0	0	0	0	0	0	—	—
Boiler replacement	0	0	0	0	0	0	0	—	—
Boiler upgrade on failure	0	0	3	1	0	<1	1	$220	$411
Boiler controls	0	0	19	5	<1	2	5	$41	$40
Boiler pipe insulation	0	2	13	13	<1	3	8	$5	$6
5-year payback									
Furnace replacement	0	0	0	0	0	0	0	—	—
Furnace upgrade on failure	30	14	2	0	27	21	11	$164	$489
Fuel switch electric heat	0	5	0	0	3	0	1	$1,154	$4,000
Boiler replacement	0	0	1	2	0	<1	1	$54	$234
Boiler upgrade on failure	0	0	4	8	<1	<1	3	$113	$269
Boiler controls	0	2	20	8	2	2	6	$39	$49
Boiler pipe insulation	0	2	13	13	<1	3	8	$5	$6
10-year payback									
Furnace replacement	20	5	0	0	15	11	7	$235	$1,891
Furnace upgrade on failure	38	24	4	0	37	29	16	$133	$485
Fuel switch electric heat	0	6	20	16	7	1	8	$620	$4,000
Boiler replacement	0	0	4	9	<1	<1	4	$82	$513
Boiler upgrade on failure	0	0	6	10	<1	1	4	$108	$375
Boiler controls	0	2	27	8	2	3	7	$37	$73
Boiler pipe insulation	0	2	13	13	<1	3	8	$5	$6

[a]Represents the percent of statewide rental housing units with cost-effective savings opportunity. For buildings with individual heating systems, only units with a heating system opportunity are included.
[b]Average savings and cost are per dwelling unit affected by the measure.

We also found that the high cost of adding distribution ductwork when replacing baseboard electric heating with gas-fired furnaces makes this option cost prohibitive, except over longer payback horizons.

Given the high capital cost of replacements, it wasn't surprising that boiler controls (hot water reset) offered one of the best opportunities for efficiency improvements. These opportunities are prevalent in the larger buildings that are most likely to be heated with a hydronic system. Savings of 7 to 15% are typical as circulating water temperature is decreased with increasing air temperature. This measure has the added benefit of increased comfort with reduced overheating. This measure can be targeted relatively easily because of the prevalence of hot water boilers in generally larger, older and more urban buildings. About 40 percent of buildings with hydronic heat lack these controls.

Air conditioning measures

The study did not reveal any cooling system improvements that met even a 10-year payback requirement. The small incremental savings between standard and high efficiency units and the limited run hours in our climate conspire to minimize the potential of cooling system savings from the end-user perspective. Given that the vast majority of air conditioned rental dwellings utilize window or sleeve units for their cooling source, the tenants are responsible for most of the cooling costs in this market.

Approximately 75% of rental units have some form of air conditioning with the highest saturation in larger buildings. Central chiller systems are relatively rare and the high capital cost tends to far outweigh the savings from a payback standpoint. The cost of new window or sleeve units is far less expensive, but the savings are small. Even on the basis of looking at replacement on failure, high-efficiency options are only marginally cost effective.

Domestic hot water measures

Domestic hot water is a significant energy user in rental buildings and there are a number of opportunities to reduce energy use for water heating. Replacement savings calculations rely on a process similar to heating and cooling systems where the building is modeled using old and new water heaters.

The energy efficiency opportunities can be summarized into four main categories:

1. Reduce usage (low flow showerheads);
2. Reduce heat loss (tank wrap, pipe insulation, reduce temperature);
3. Improve efficiency (broken into small and large system replacement);
4. Conversions from electric to natural gas.

There is an opportunity to reduce hot water usage by replacing showerheads that use 2.5 gallons per minute (gpm) or more with new, 1.75 gpm pulsating showerheads. This retrofit provides 30% or more reduction of hot water used in showers. This is a low-cost measure that provides for a quick payback (generally under one year).

Another quick payback and easy to implement energy savings opportunity is reducing the temperature of the domestic hot water heater to 125 degrees. This measure has no cost associated with it which provides for an instantaneous payback. About a quarter of rental units have measured temperature of 135 degrees Fahrenheit or more.

Replacing water heaters (without fuel switch) for efficiency reasons is rarely cost justified. The exception is central water heaters that serve many units in larger buildings. Even here, the payback period is considerable.

TABLE 20. WATER HEATING OPPORTUNITIES

	PERCENT OF BUILDINGS WITH OPPORTUNITY								
	UNITS IN BUILDING				LOW-INCOME BUILDING?		PERCENT OF UNITS[a]	AVERAGE SAVINGS AND COST PER AFFECTED DWELLING UNIT[b]	
	1	2-4	5-19	20+	YES	NO		SAVINGS	COST
2-year payback									
Fuel switch electric	0	0	1	5	<1	0	1	$136	$164
Temperature reduction	28	49	60	38	37	43	33	$13	$0
Replacement (small)	0	0	0	0	0	0	0	—	—
Replacement (large)	0	0	0	0	0	0	0	—	—
Wrap	47	40	36	51	53	39	43	$11	$15
Showerheads	61	81	70	93	83	59	74	$28	$10
Pipe insulation	44	32	41	27	54	27	35	$7	$6
5-year payback									
Fuel switch electric	35	1	1	12	18	26	11	$227	$562
Temperature reduction	28	49	60	38	37	43	33	$13	$0
Replacement (small)	0	0	0	0	0	0	0	—	—
Replacement (large)	0	0	0	8	0	0	2	$36	$118
Wrap	76	82	75	84	79	83	77	$9	$18
Showerheads	61	81	70	93	83	59	74	$28	$10
Pipe insulation	44	32	41	27	54	27	35	$7	$6
10-year payback									
Fuel switch electric	35	10	1	12	22	28	13	$208	$569
Temperature reduction	28	49	60	38	37	43	33	$13	$0
Replacement (small)	0	0	1	0	0	0	0	$17	$150
Replacement (large)	0	0	1	23	0	0	6	$24	$125
Wrap	76	85	82	93	80	85	81	$9	$18
Showerheads	61	81	70	93	83	59	74	$28	$10
Pipe insulation	44	32	41	27	54	27	35	$7	$6

Represents the percent of statewide rental housing units with cost-effective savings opportunity. For buildings with individual water heaters, only housing units served by a system with an opportunity are included.
[b]Average savings and cost are per dwelling unit affected by the measure.

Appliance Measures

This study collected information on two appliances that use a significant amount of energy in residential housing: refrigerators and clothes washers. Refrigerators consume a large amount of electricity due to their ubiquity and the fact that they operate year round, 24 hours per day. Clothes washers do not consume much electricity in and of themselves, but the hot water they use represents a non-trivial proportion of hot water consumption.

We evaluated the savings and cost effectiveness of replacing these appliances with ENERGY STAR labeled units, which can be said in both cases to use about half of the energy of a typical existing unit. To meet a particular payback threshold, the savings from replacing the unit must justify the cost of replacement. While the large majority of existing units use more energy than an ENERGY STAR labeled counterpart, it is the payback threshold that limits the incidence rate for these measures. Few refrigerators and individual washing machine replacements can be justified on the basis of a 2-year payback or less. On the other hand, a substantial fraction of the existing stock could be replaced under a 10-year payback threshold. Washing machines in common laundry rooms in larger buildings—which typically receive heavy use—represent significant opportunities with short payback periods.

TABLE 21. APPLIANCE OPPORTUNITIES

	PERCENT OF BUILDINGS WITH OPPORTUNITY						PERCENT OF UNITS[a]	AVERAGE SAVINGS AND COST PER AFFECTED DWELLING UNIT[b]	
	UNITS IN BUILDING				LOW-INCOME BUILDING?				
	1	2-4	5-19	20+	YES	NO		SAVINGS	COST
2-year payback									
Refrigerator repl.	0	0	0	0	0	0	0	—	—
Washer repl.									
in-unit	0	0	0	0	0	0	0	—	—
common laundry	0	2	10	44	2	1	12	$20	$29
5-year payback									
Refrigerator repl.	14	17	11	18	12	17	11	$135	$461
Washer repl.									
in-unit	0	0	0	0	0	0	0	—	—
common laundry	0	9	43	71	7	7	30	$19	$41
10-year payback									
Refrigerator repl.	45	33	51	53	50	33	33	$93	$455
Washer repl.									
in-unit	33	14	6	5	23	28	15	$49	$313
common laundry	0	18	52	81	8	13	36	$18	$53

[a]Represents the percent of statewide rental housing units with cost-effective savings opportunity. For washer replacement in buildings with common laundry, all units in the building are deemed affected.
[b]Average savings and cost are per dwelling unit affected by the measure.

Lighting Measures

The discussion of energy efficiency potential in lighting can be broken down between in-unit and common area lighting. Tenants overwhelmingly would see the electric-bill savings from in-unit lighting upgrades, while upgrades in common-areas accrue to owners.

The best opportunities in common-area lighting revolve around high burn time fixtures, namely exit signs and 24-hour hallway lighting. Fixtures that are on less than 24-hours can also be good targets and potentially cost effective retrofits. Lighting controls (timers, occupancy and ambient light sensors) are effective in reducing the number of hours of operation in long burn time settings.

The on-site data collection of existing common-area lighting showed that most common-area lighting in small multifamily buildings is still incandescent—though not all smaller multifamily buildings have common areas. On the other hand, large buildings, which all have common-area lighting, have already largely been converted to fluorescent lighting. In this sense, the calculated incidence for common-area lighting improvements in large buildings is misleading when viewed in isolation: while most large buildings have opportunities for common-area lighting upgrades, these tend to be confined to a small number of fixtures in each building.

For this reason, most of the aggregate potential for lighting efficiency upgrades lies not in common areas, but rather inside apartment units. Although the hours of operation for in-unit lighting tends to be less, there are large lighting upgrade opportunities in apartment units because incandescent lamps make up nearly 90% of the bulbs.

The analysis suggests that while common-area improvements represent about two-thirds of the total lighting savings opportunities in 2-4 unit buildings, common-area lighting comprises less than 15 percent of the lighting savings potential in 20+ unit buildings. Moreover, the data suggest that more than three-quarters of the total common-area lighting savings potential is in 2-4 unit buildings, even though many of these buildings lack common areas entirely.

TABLE 22. LIGHTING OPPORTUNITIES

	PERCENT OF BUILDINGS WITH OPPORTUNITY						PERCENT OF DWELLING UNITS[a]	AVERAGE SAVINGS AND COST PER AFFECTED DWELLING UNIT[b]	
	UNITS IN BUILDING				LOW-INCOME BUILDING?				
	1	2-4	5-19	20+	YES	NO		SAVINGS	COST
2-year payback									
LED exit lights	0	0	3	10	<1	1	3	$4	$7
Common-area lighting replacement	0	2	12	25	<1	3	8	$29	$38
In-unit lighting replacement	100	99	100	100	100	99	100	$42	$36
Outdoor/entry lighting controls	33	24	15	7	26	28	20	$192	$61
5-year payback									
LED exit lights	0	2	15	26	1	3	10	$6	$13
Common-area lighting replacement	0	28	77	69	10	19	39	$28	$85
In-unit lighting replacement	100	99	100	100	100	99	100	$49	$57
Outdoor/entry lighting controls	36	33	30	17	33	34	30	$130	$48
10-year payback									
LED exit lights	0	2	20	56	1	4	17	$5	$16
Common-area lighting replacement	0	43	87	69	16	24	46	$25	$83
In-unit lighting replacement	100	100	100	100	100	100	100	$49	$62
Outdoor/entry lighting controls	36	33	30	18	33	34	30	$129	$48

[a]Represents the percent of statewide rental housing units with cost-effective savings opportunity. For common-area lighting and controls, all units in building are deemed affected.
[b]Average savings and cost are per dwelling unit affected by the measure.

TENANT DEMOGRAPHICS, ATTITUDES AND BEHAVIOR

More than one in four Wisconsin residents live in rental housing. Table 23 shows various demographic characteristics of multifamily renters based on the tenant survey data collected for the project.[8] Overall, multifamily rental households tend to be smaller than homeowners. More than a third are single-person households, a proportion that is more than twice as high as that of homeowners. Not surprisingly, rental households are more mobile; nearly two-thirds have lived at their current address for two years or less. (In contrast, more than half of Wisconsin homeowners have lived in their home for more than a decade.)

Renters also tend to have lower incomes than homeowners; overall, about one in three multifamily rental households has income below 150 percent of the federal poverty guideline, a proportion that is more than double that of single-family homeowners.

The demographics of multifamily renters also vary by building size. As Table 23 shows, larger buildings are more likely to house single-person households and seniors, and are less likely to have households with children.

The National Multi Housing Council has segmented renters into three broad categories[9]:

- Low and moderate income renters
- Lifesytyle renters
- Middle-market renters

The low and moderate income segment comprises renters at the lower end of the income distribution who cannot afford to own a home. At the other end of the spectrum, lifestyle renters have the income to afford homeownership, but choose to be renters. The middle-market is defined by renters who are neither low income nor luxury-market renters. While we did not attempt to explicitly segment tenant survey respondents in this manner, the data suggest that all three segments do exist in the Wisconsin rental market.

[8] Because only 29 single-family buildings were included in the study, and the tenant survey has a 40 percent response rate, too few tenant respondents were obtained to provide reliable information on single-family rental households.

[9] See Goodman, Jack, "The changing Demography of Multifamily Rental Housing," *Housing Policy Debate*, vol. 10, Issue 1, 1999. Available from www.nmhc.org.

TABLE 23. TENANT DEMOGRAPHICS, MULTIFAMILY BUILDINGS

	UNITS IN BUILDING			LOW-INCOME HOUSEHOLD[a]		HEAT PAID BY TENANT?		OVERALL
	2-4	5-19	20+	YES	NO	YES	NO	(MULTIFAMILY)
Household composition								
Household members (mean)	2.8	2.6	1.7	3.2	1.9	2.6	2.1	2.4
% single person household	18	45	64	24	47	26	55	38
% w/ senior	5	10	23	15	9	8	15	11
% w/ children	44	18	11	44	20	37	13	27
% unrelated roommates	24	23	11	28	16	23	18	21
Years in current unit								
< 1 year	34	37	37	47	28	36	35	36
1-2 years	30	29	25	25	33	31	25	28
3-4 years	9	13	14	9	13	9	16	12
5-10 years	13	15	15	8	18	12	16	14
11+ years	14	6	9	11	8	12	8	10
Education[b]								
Grade school	1	1	3	3	1	2	2	2
High school	12	19	22	27	11	14	21	17
Technical school	46	27	16	28	35	41	19	32
Undergrad. college	39	44	45	38	44	40	45	42
Advanced college	2	9	14	4	9	3	13	7
Income (2001 annual)								
<$5,000	2%	6%	11%	15%	0%	6%	5%	6%
$5,000 - $9,999	13%	10%	13%	32%	0%	12%	11%	12%
$10,000 – $14,999	13%	11%	15%	30%	3%	13%	13%	13%
$15,000 - $19,999	5%	8%	11%	7%	8%	6%	10%	8%
$20,000 - $24,000	12%	7%	10%	10%	9%	11%	8%	10%
$25,000 - $29,999	11%	9%	9%	0%	16%	10%	10%	10%
$30,000 - $34,999	9%	13%	7%	0%	15%	8%	11%	9%
$35,000 - $49,999	31%	20%	13%	5%	33%	25%	19%	23%
$50,000 - $74,999	4%	13%	9%	1%	12%	7%	9%	8%
$75,000+	0%	5%	4%	0%	4%	2%	4%	3%
% Low-income[a]	40	29	38			39	31	36
Sample size	76	226	435	275	414	311	434	737

[a]Household income at or below 150% of 2001 Federal Poverty Guideline.

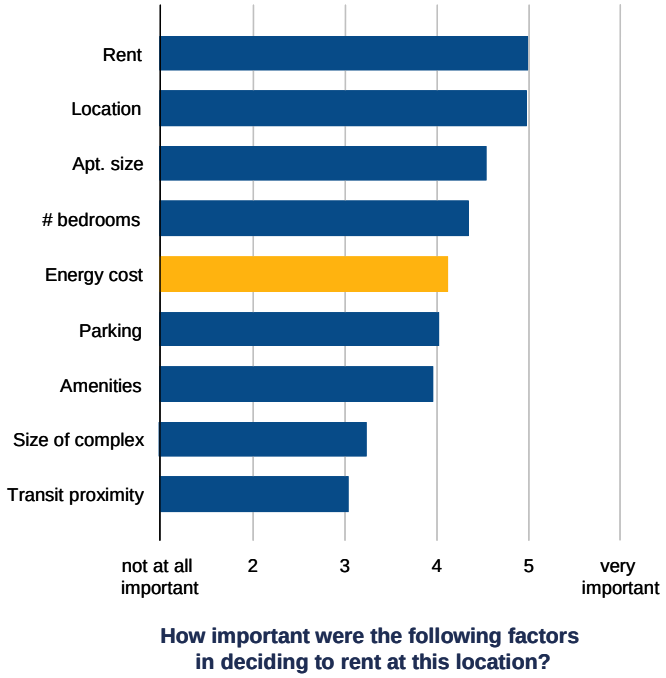
[b]Highest level reported for any adult household member. Includes completion of coursework w/o degree.

Rent amount, building location, and the size of the apartment are the strongest drivers in influencing why people choose to rent where they do (Figure 14).[10] Energy costs rate in the middle of the pack, at about the same level of importance as factors such as parking and other amenities. These rankings are similar across various building sizes as well as across renters who pay their heating costs directly versus those where heating is included in the rent.

Low-income renters rate the importance of energy costs slightly higher than non low-income renters, a difference that is statistically significant at a 90% confidence level. Nonetheless, low-income renters differ from non low-income renters far more on issues related to transportation—placing significantly less importance on parking and more importance on proximity to mass transit.

Similarly, landlords indicate that most tenants do not inquire about energy costs when looking into renting an apartment in their building (Table 24).

FIGURE 14. FACTORS IN DECIDING WHERE TO RENT



[10] We obtained nearly identical rankings from owner/manager survey respondents of what is important to tenants when choosing where to rent.

TABLE 24. PROPORTION OF TENANTS WHO INQUIRE ABOUT ENERGY COSTS

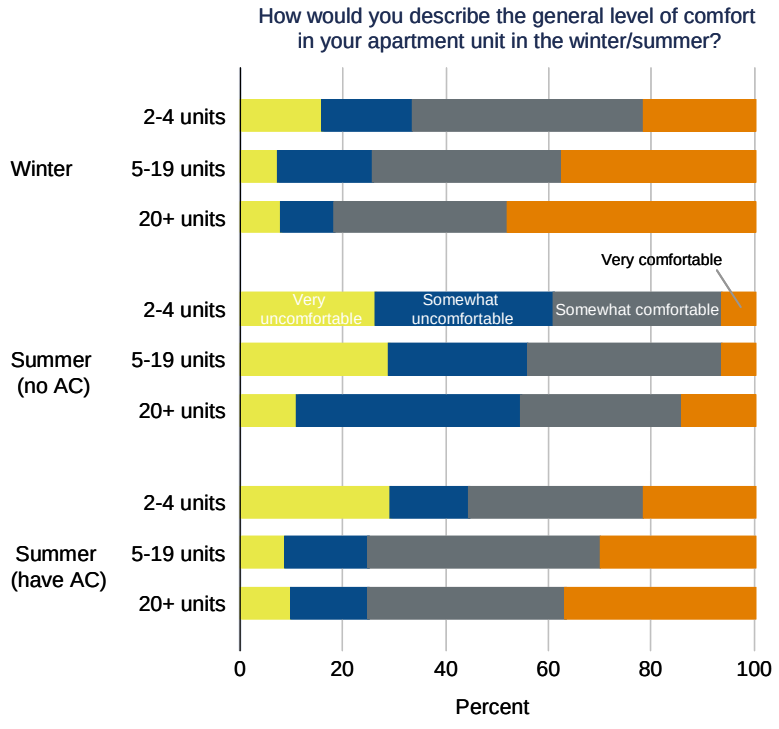
"WHEN PROSPECTIVE TENANTS ARE LOOKING TO RENT IN THIS BUILDING, WHAT PERCENT OF THEM ASK ABOUT ENERGY COSTS?" (OWNER/OPERATOR QUESTIONNAIRE)									
	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		
	1	2-4	5-19	20+	YES	NO	YES	NO	OVERALL
None	20%	10%	7%	12%	6%	21%	16%	13%	16%
<25%	36%	35%	32%	30%	37%	33%	35%	32%	35%
26-50%	18%	20%	13%	13%	24%	15%	17%	32%	18%
51-75%	9%	11%	17%	33%	8%	12%	11%	5%	10%
>75%	17%	24%	32%	11%	25%	18%	20%	18%	20%
Sample size	27	44	47	39	40	114	94	62	157

Comfort

APARTMENT COMFORT

The tenant survey asked respondents to rate the general level of comfort in their apartment during the winter and the summer. The results indicate that comfort is generally higher in larger buildings and lower in smaller buildings. While comfort ratings for tenants of large buildings (20+ units) are on par with those reported by homeowners in the earlier characterization study of single-family owner-occupied housing, tenants of 2-4 unit buildings report lower levels of winter comfort: more than a third report that their apartments are somewhat or very uncomfortable during the winter, and only about one in five report being very comfortable during the winter.

FIGURE 15. TENANT COMFORT IN THE WINTER AND SUMMER



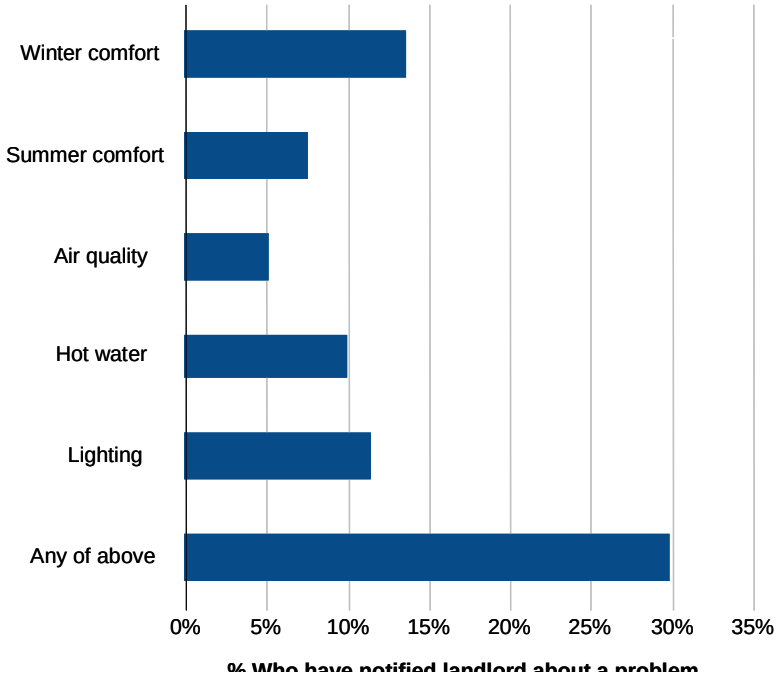
Tenants of multifamily buildings, n=682(summer) n=560 (winter)

The owner/manager survey similarly asked landlords to assess the comfort level of their buildings. The landlord assessments of comfort tended to track with the tenant assessments in terms of operators of larger buildings reporting better comfort than operators of smaller buildings. However, the landlord assessments of comfort tended to be more extreme than those of tenants. More than two-thirds of operators of 20+ unit buildings—and three-quarters of operators of 5-19 unit buildings described their building as being "very comfortable" in the winter. Perhaps most surprising, however, is that fully a quarter of operators of 2-4

unit buildings described winter comfort in their building as "very uncomfortable," a proportion that is higher than that of the tenants themselves.

Nearly one in three tenants report notifying their landlord about a temperature, air quality, lighting or hot water issue during the previous year (Figure 16). We found no relationship between the frequency of these complaints and the size of the building, however.

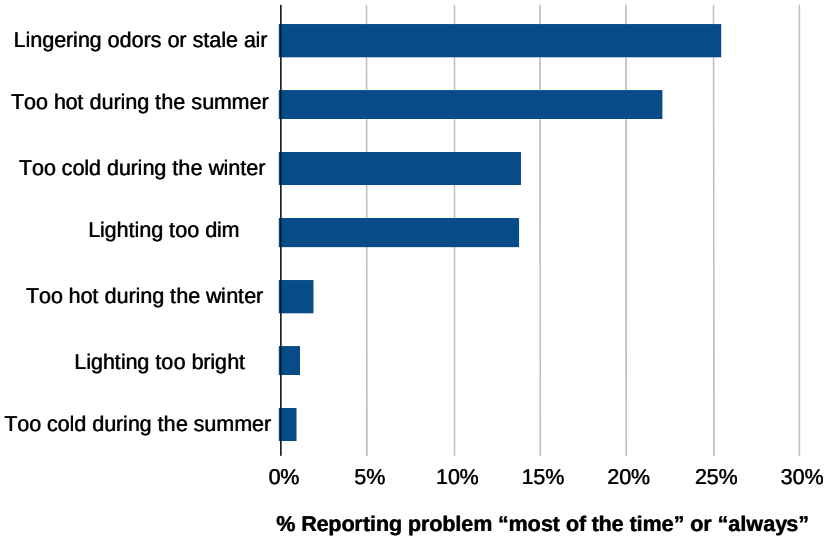
FIGURE 16. INCIDENCE OF REPORTING AN APARTMENT COMFORT PROBLEM TO LANDLORD.



COMMON-AREA COMFORT ISSUES

Among tenants of buildings with common areas, lingering odors and temperature problems lead the list of reported comfort issues in common areas (Figure 17). More than one in four tenants reported problems with lingering odors or stale air in common areas "most of the time" or "always," and a slightly lower proportion reported issues with common areas being too warm during the summer. As with apartment comfort, common-area comfort issues are more prevalent among tenants of smaller buildings. However, only about one in seven tenants report having notified their landlord about a common-area comfort problem during the previous year.

FIGURE 17. INCIDENCE OF COMMON-AREA COMFORT ISSUES.



Tenant Attitudes about Energy

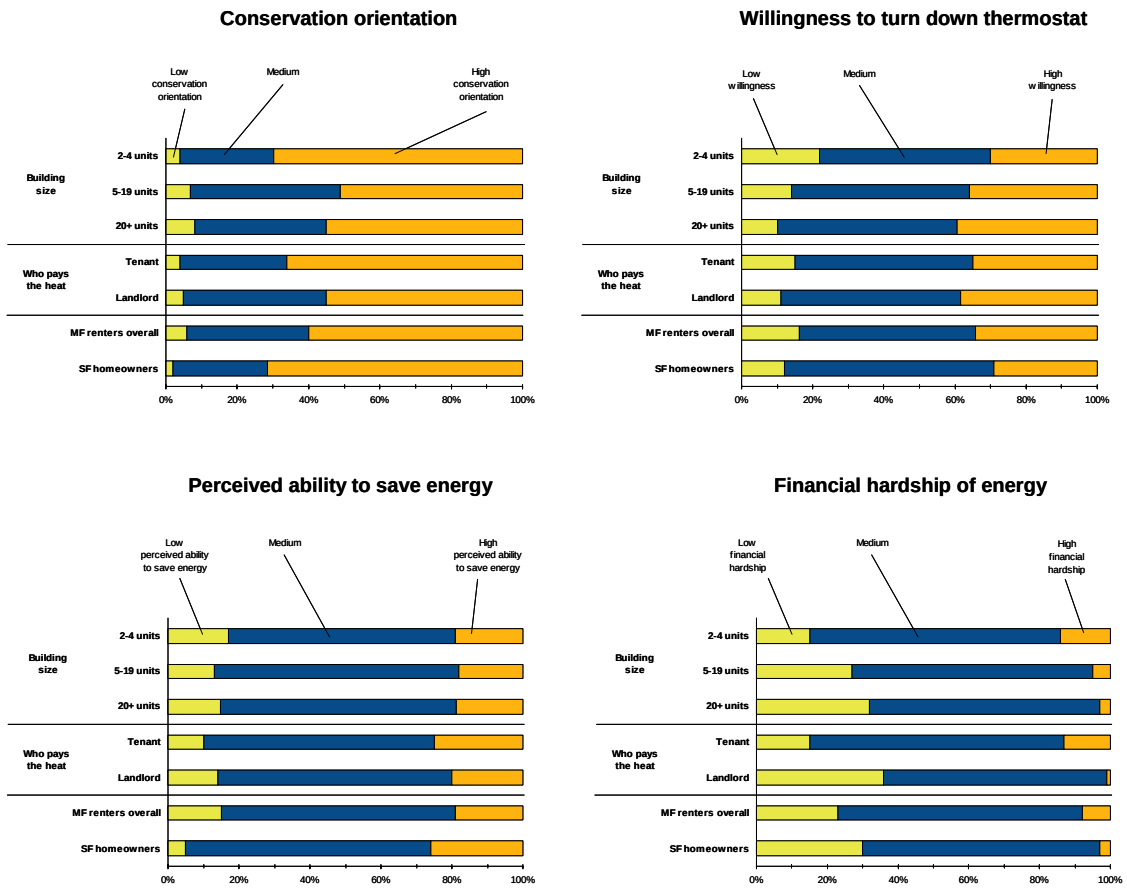
Following a method employed in the previous study of single-family homeowners, we included a series of attitude statements on the tenant questionnaire, and asked renters to indicate how much they agreed or disagreed with those statements. Two examples of such statements are: "It's just not worth putting on more clothing in the winter to try to save a little energy," and "It's my right to use as much energy as I

want, as long as I pay for it." We then aggregated these statements into four broader indices that were developed as part of the prior homeowner study:

- Conservation orientation
- Willingness to turn down the thermostat
- Perceived ability to save energy
- Financial hardship of energy

As Figure 18 shows, multifamily renter scores for these indices largely mirror those of homeowners. Most tenants profess being highly oriented toward energy conservation, have some willingness to further reduce winter thermostat temperatures, have moderate perceptions of the ability to save energy, and are generally moderate about the hardship that energy costs impose on them. Nonetheless, there are some differences between renters and homeowners at the extremes. Multifamily renters in general are somewhat less likely to perceive additional opportunities to save energy in their home, and are somewhat more likely to feel that energy costs are a financial burden on their household (not surprisingly, low-income tenants are much more likely to perceive such hardship). These differences are no doubt reflective of the fact that renters have less control over their environment than homeowners, and generally have lower incomes.

FIGURE 18. ATTITUDE INDEX SCORES



Based on 681 to 693 responses, depending on index
Source for SF homeowner data, "Energy and Housing" ECW 2000 (n=299)

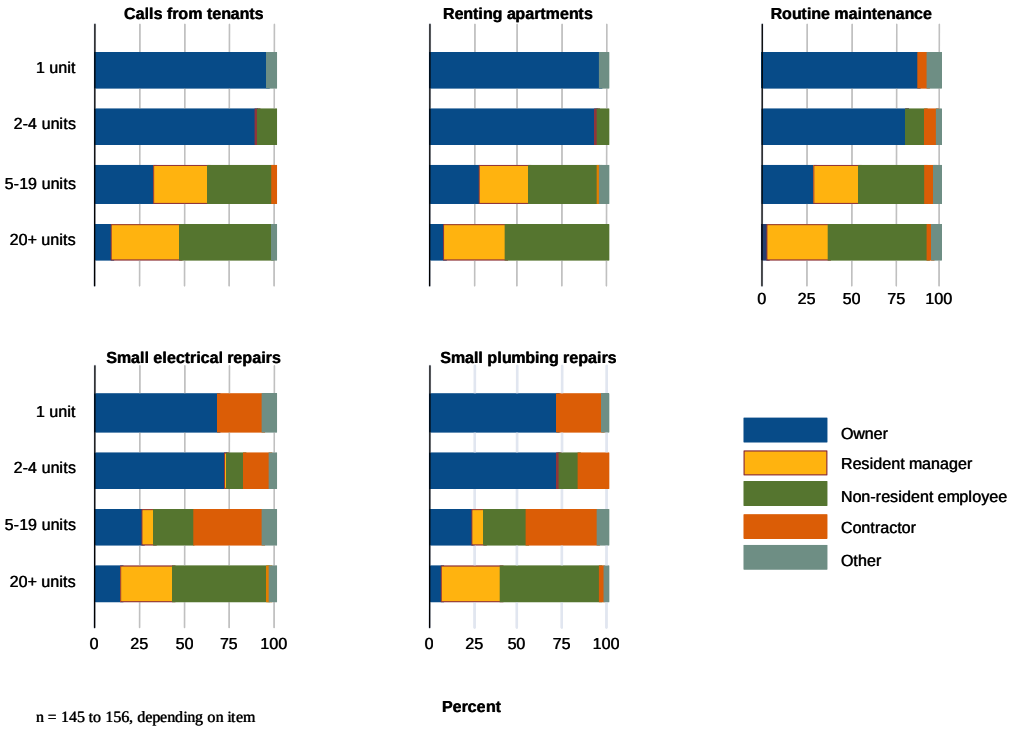
BUILDING OWNERSHIP, MANAGEMENT AND DECISION-MAKING

The owner/manager survey data indicate that individual investors dominate the ownership of Wisconsin rental properties for all but the largest buildings (Table 25). Moreover, for smaller buildings, it is overwhelmingly the owner who directly handles routine activities such as renting apartments and responding to tenant complaints (Figure 19). In larger buildings, resident or non-resident managers handle these tasks.

TABLE 25. BUILDING OWNERSHIP

	units in building				low-income building?		
	1	2-4	5-19	20+	Yes	No	Overall
Individual investors	70%	84%	71%	42%	85%	67%	74%
Partnership	9%	9%	10%	45%	9%	10%	9%
Corporation	3%	2%	13%	3%	1%	2%	3%
Non-profit	3%	0%	1%	6%	5%	<1%	2%
Real estate invest. trust	0%	5%	0%	0%	0%	3%	2%
LLC	5%	0%	1%	4%	0%	6%	3%
Other	10%	0%	4%	0%	0%	12%	6%
Study sample	27	45	48	39	62	94	159

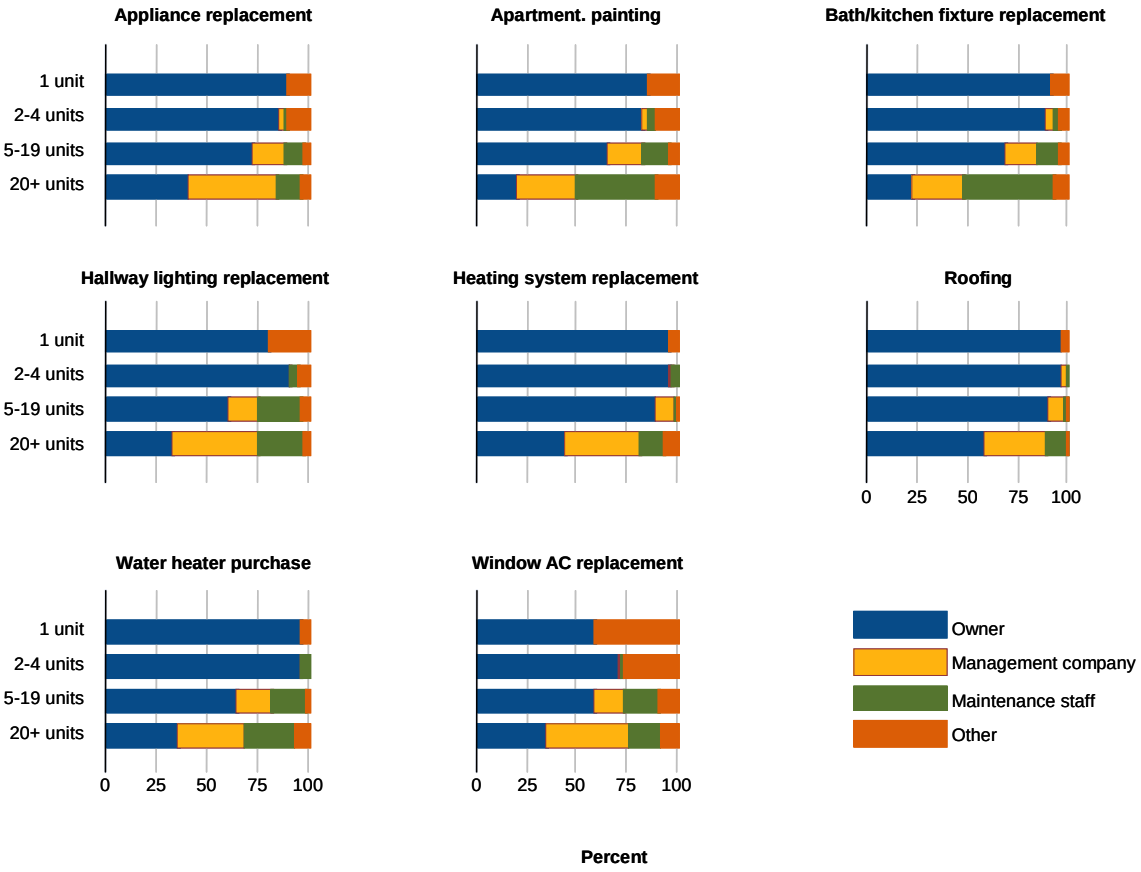
FIGURE 19. WHO HANDLES BUILDING MANAGEMENT ACTIVITIES, BY BUILDING SIZE.



n = 145 to 156, depending on item

Owners of small buildings also make most of the decisions about replacing equipment and upgrading apartments (Figure 20). For larger buildings (5+ units), these responsibilities tend to be spread over a more diverse group of owners, resident mangers, non-resident managers, maintenance staff, and outside contractors.[11]

FIGURE 20. WHO MAKES DECISIONS ABOUT UPGRADES AND EQUIPMENT REPLACEMENT, BY BUILDING SIZE.



[11] This distinction is also largely reflected in the makeup of respondents to the survey itself: 66 of 72 respondents (92%) for buildings with 1-4 units were owners. For the 89 buildings with five or more units, the survey respondents represented a more diverse group: owner, 43%; resident manager, 20%; no-resident manager, 32%; other or unknown, 5%.

Appliance purchase practices

The owner/manager survey data indicate that replacing appliances is a fairly routine activity in larger buildings, but is infrequent in smaller buildings (Table 26). This reflects that larger buildings have more units with appliances, as well as the fact that the landlord is more likely to be responsible for the appliances in larger buildings. The vast majority (more than 90%) of refrigerators in 5+ unit buildings are provided with the rental unit, compared to only about half of single-family rental units and 60 percent of 2-4 unit buildings. These proportions are similar for other appliances such as ranges and dishwashers—though only about half of units have the latter at all.

TABLE 26. APPLIANCE PURCHASE RATES REPORTED BY OWNER/MANAGERS

"HAVE YOU INSTALLED OR PURCHASED ANY OF THE FOLLOWING MAJOR APPLIANCES FOR THIS BUILDING IN THE PAST TWO YEARS?" (PERCENT "YES")							
	UNITS IN BUILDING				LOW-INCOME BUILDING?		
	1	2-4	5-19	20+	YES	NO	OVERALL
Refrigerator	0%	21%	49%	78%	7%	17%	12%
Freezer	0%	5%	0%	0%	3%	0%	2%
Room AC	16%	2%	17%	57%	20%	8%	13%
Dishwasher	4%	1%	17%	40%	6%	3%	4%
Clothes washer	0%	14%	26%	29%	4%	9%	6%
Clothes dryer	0%	12%	17%	28%	3%	8%	5%
Study sample	19	40	44	37	54	83	140

The owner/manager survey data suggest that rental operators purchase 30,000 to 40,000 refrigerators and room air conditioners each year in Wisconsin, along with lesser numbers of other appliances (Table 27). The majority of these purchases are replacements for existing units.

TABLE 27. ESTIMATED STATEWIDE ANNUAL APPLIANCE PURCHASES BY WISCONSIN LANDLORDS

APPLIANCE	NUMBER PURCHASED ANNUALLY	PERCENT REPLACING EXISTING
Room air conditioner	40,000	79
Refrigerator	36,000	97
Dishwasher	14,300	80
Clothes washer	10,000	92
Clothes dryer	2,500	86
Stand-alone freezer	1,800	64

Overall in the rental sector, more than half of owner/operators report making appliance purchase decisions on the spot (Table 28), but this is mostly driven by the large number of operators of small buildings who replace appliances infrequently. Nearly half of operators of large buildings (20+ units) reported using pre-negotiated contracts for appliance purchases. Nonetheless, it is still somewhat surprising that a full quarter of appliances for large buildings are purchased through on-the-spot selection of available models.

Nearly two-thirds of operators report purchasing appliances through a local or regional retail appliance dealer, though about a quarter of operators of large buildings buy directly from distributors or wholesalers. Few respondents reported mainly buying used appliances, but a substantial proportion of operators of small buildings report doing so at least occasionally. Operators of larger buildings rarely purchase used appliances.

TABLE 28. APPLIANCE PURCHASE PRACTICES

	UNITS IN BUILDING				LOW-INCOME BUILDING?		
	1	2-4	5-19	20+	YES	NO	OVERALL
Appliance purchase process							
Pre-negotiated contract	22%	5%	23%	44%	14%	20%	17%
Bidding process	22%	2%	22%	10%	22%	9%	15%
On-the-spot selection	44%	83%	47%	25%	45%	64%	56%
Other	13%	10%	8%	21%	18%	6%	12%
Where appliances are purchased							
Appliance dealer	77%	39%	70%	57%	65%	59%	63%
National chain	0%	43%	9%	11%	9%	23%	16%
Distributor/Wholesaler	14%	7%	13%	25%	13%	11%	12%
Manufacturer	0%	0%	4%	6%	<1%	<1%	<1%
Other	9%	11%	3%	1%	13%	6%	9%
Used or New?							
Always new	38%	42%	74%	95%	20%	57%	44%
Mostly new	39%	18%	16%	2%	46%	19%	29%
Sometimes used/new	14%	33%	9%	2%	26%	17%	20%
Mostly used	9%	1%	1%	0%	6%	5%	5%
Always used	0%	7%	0%	0%	2%	2%	2%
Study sample	18	39	48	39	55	87	144

Respondents were also asked to rate the importance of various factors in their purchasing decisions on a scale of 1 (“not at all important”) to 4 (“very important”). These included:

- Life
- Price
- Past experience with the brand
- Reliability
- Ease of maintenance
- Identical or similar model as existing unit
- Energy use

With one exception, respondents tended to rate all of the factors highly—regardless of building size—with 80 to 90 percent of respondents scoring each factor at least 3 out of 4 in importance. (This result at some level calls into question whether the question was posed in an overly broad manner.) The (statistically significant) exception is the importance of replacing an appliance with an identical or similar

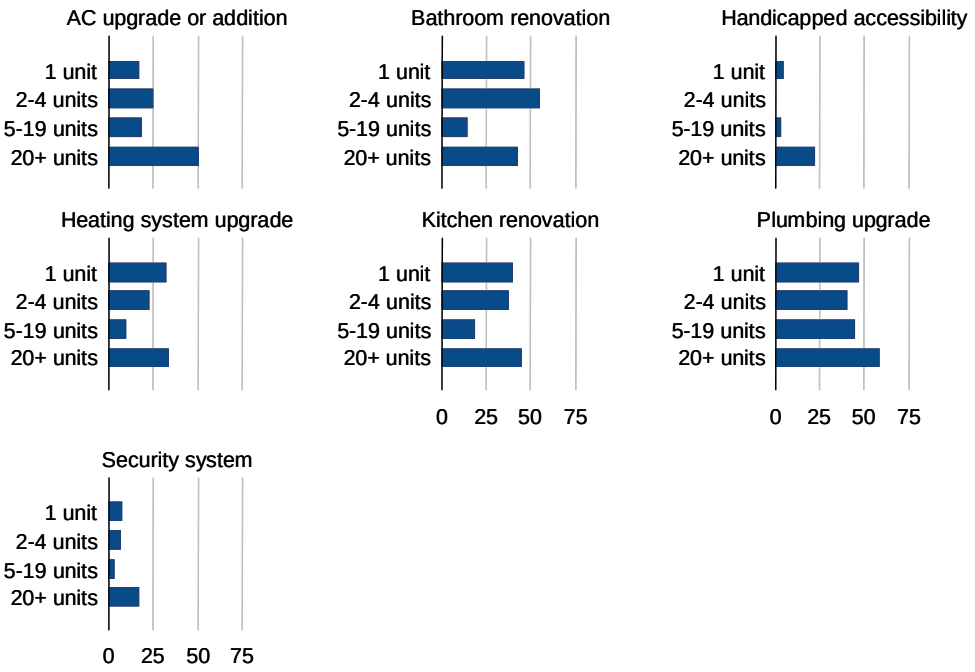
model: operators of small buildings (1-4 units) give this factor a low importance (mean score: 1.8), while operators of large buildings rate it more highly (mean score: 2.6).

Building upgrades and repairs

The National Multi Housing Council (NMHC) estimates that 85,000 dwelling units in Wisconsin 5+ unit buildings are upgraded each year, with total spending on these upgrades of about $100 million annually.[12] If accurate, this would imply that about 30 percent of Wisconsin apartments are upgraded each year.

We asked owners and mangers about building changes over a five year period, using categories from the NMHC report. The survey results (Figure 21) tend to support the notion of significant activity in upgrades and mechanical system replacement in rental buildings, though at a lower rate than estimated by NMHC. For 5+ unit buildings, the survey data imply that about two-thirds of 5+ unit buildings receive some kind of upgrade over a five-year period, or about 12 to13 percent per year.

FIGURE 21. REPORTED BUILDING CHANGES, BY BUILDING SIZE.



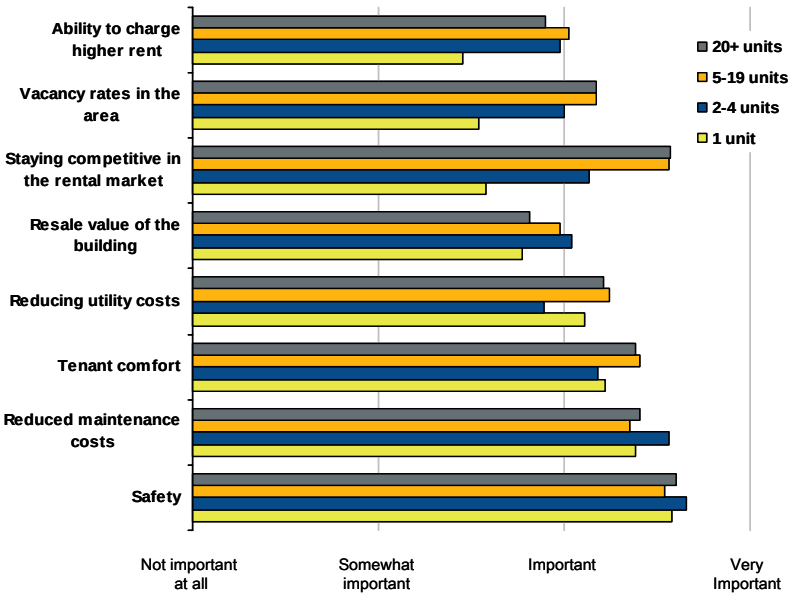
[12] *Capital Improvements to Apartments: Projections for States and Metro Areas*, National Multi Housing Council (NMHC), 2000. (Available from www.nmhc.org.)

The survey data suggest that renovations to single-family rental homes and small multifamily buildings are actually more common than those for larger rental buildings: nearly 80 percent of 1-4 unit buildings receive one of the changes shown in Figure 21 over a five-year period. Ambiguity in the question wording may have resulted in some fairly minor changes being counted along with more extensive upgrades, with the result that the survey data may overstate the overall incidence of major upgrade activities. For example, all building sizes show a fairly high incidence of "plumbing upgrades or changes." However, some respondents may have included minor repairs such as replacing a leaky faucet in this category.

Nonetheless, the data do indicate that there is significant activity in rental unit renovation, and that many of these upgrades have energy related aspects to them. Aside from the obvious energy connection for heating systems and air conditioners, energy efficiency opportunities exist for refrigerator replacement with kitchen renovation, and showerhead replacement with bathroom renovation.

We also asked owners and mangers about the importance of various factors when deciding whether to make changes to their building. As with a similar question related to appliance purchasing, most respondents tended to rate all of the factors fairly highly (Figure 22), suggesting that the responses were somewhat off-the-cuff. However, it is notable that landlords of single-family properties place significantly less importance on the ability to charge higher rent, vacancy rates, and staying competitive in the market.

FIGURE 22. LANDLORD FACTORS IN DECIDING WHETHER TO MAKE BUILDING CHANGES,



Building operating costs

The owner/manger questionnaire asked respondents to identify the first, second, and third highest items contributing to their operating cost from the list below[13]:

- Taxes
- Mortgage/interest/insurance
- Energy and other utilities
- Maintenance and repairs
- Management fees

These rankings provided by the survey respondents indicate that mortgage, insurance, and taxes are the top costs for the vast majority of rental operators, though nearly a quarter of single-family operators report maintenance as their top operating cost. Utility costs tend to rank third among operators who include heat in the rent, but infrequently are cited as even being in the top three among other landlords.

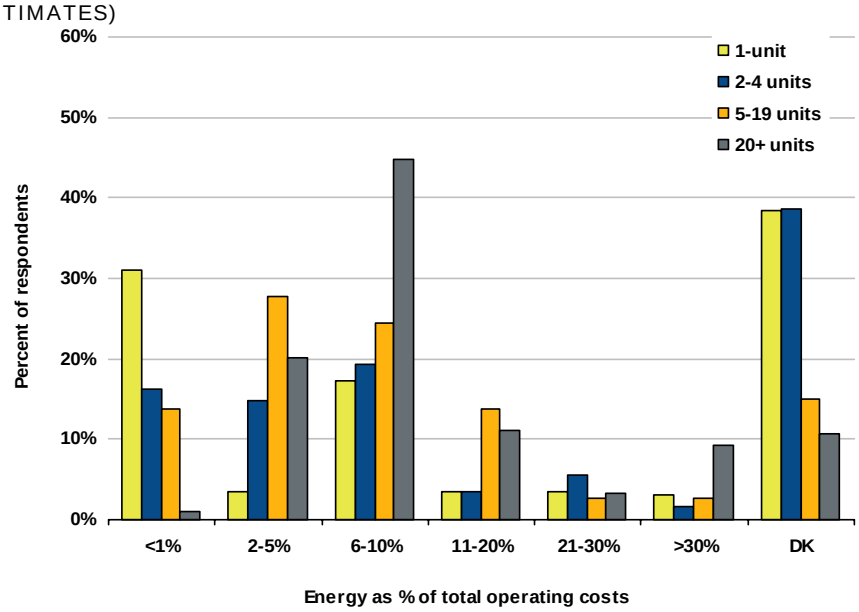
TABLE 29. OPERATING COST RANKINGS

	UNITS IN BUILDING				LOW-INCOME BUILDING?		HEAT PAID BY TENANT?		
	1	2-4	5-19	20+	YES	NO	YES	NO	OVERALL
Top operating cost cited									
Mortgage/int./ins.	29%	65%	80%	73%	44%	47%	41%	69%	43%
Taxes	46%	32%	14%	16%	38%	41%	41%	25%	40%
Maint./repairs	22%	0%	0%	4%	13%	11%	15%	0%	14%
Management fees	0%	0%	1%	2%	0%	0%	0%	0%	0%
Energy/utilities	3%	3%	5%	5%	5%	1%	3%	6%	3%
Percent where energy is cited as second or third highest operating cost									
Second highest	9%	0%	13%	17%	9%	5%	6%	9%	6%
Third highest	10%	33%	25%	34%	24%	14%	13%	64%	18%

[13] Respondents could also specify "Other," though none did so.

Owner/operators of smaller buildings were most likely to estimate that energy bills make up less than five percent of total operating costs; operators of larger buildings were more likely to cite 5 to 10 percent. It is also noteworthy that more than a third of operators of small properties did not know how much energy contributed to their overall operating costs.

FIGURE 23. ENERGY AS A PERCENT OF TOTAL OPERATING COSTS (OWNER/OPERATOR ESTIMATES)



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