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May 1984 to September 1988 Summary of Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units

by
Robert D. Neathammer

Congress directed the construction of 200 units of manufactured/factory-built housing at Fort Irwin, CA, in 1982 to see if this method of construction will cost less than conventional housing, yet still provide durable housing commensurate with contemporary housing standards.

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To compare these two types of construction properly, DOD must reliably identify O&M costs and user satisfaction. Differences in O&M costs must be identified and the reasons for those differences determined.

This is the fifth of five interim reports on the progress of the study. USACERL will provide a yearly summary for each of FY84-FY88. A final report covering the first 5 years of O&M costs will be written at the end of FY89.

No conclusions or inferences should be made as to which type of construction has the lowest O&M costs until the final 5-year summary is complete.

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FOREWORD

This research was conducted for the U.S. Army Engineering and Housing Support Center (USAEHSC), under the following Intra Army Orders (IAOs) from Fort Irwin and Headquarters, U.S. Army Forces Command: FHAA022-83, dated August 1983; R039-84, dated May 1984; S040-85, dated January 1985; T016-86, dated November 1986; CERL-87, dated December 1987, and CERL-88, dated June 1988. The USAEHSC Technical Monitor was Mr. Alex Houtzager, CEHSC-HM.

The work was performed by the Facility Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USACERL). The Principal Investigator was Mr. Robert Neathammer. Assistance was provided by Mr. Robert Doerr, Mr. Thomas Napier, Ms. Mary Chionis, Mr. William Dolan, Mr. John Shonder, Mr. Victor Storm, Ms. Darcy Weber, and Mr. Larry Augustine. Mr. Michael J. O'Connor is Chief of USACERL-FS. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

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CONTENTS

	Page
DD FORM 1473	1
FOREWORD	3
LIST OF TABLES AND FIGURES	5
1 INTRODUCTION	7
Background	
Objective	
Approach	
Scope	
2 REVIEW OF TEST PLAN	9
3 DESCRIPTION OF THE FAMILY HOUSING UNITS	10
Manufactured Housing Units (MHUs)	
Conventionally Built Units (CBUs)	
4 DATA COLLECTION PROCEDURES	11
Data Collection	
Data Verification	
Data Analysis	
5 WHOLE HOUSE ENERGY TESTS	13
House Tightness	
Furnace Efficiency	
Wall Heat Transfer Characteristics	
6 OPERATION AND MAINTENANCE (O&M) COSTS	14
Overall Costs	
Discussion	
Frequencies of Maintenance Per Housing Unit	
Maintenance Per Component	
Self-Help Repairs	
7 ENERGY COSTS	18
Electricity Consumption	
Gas Consumption	
Cost Comparison Summary	
Comments	
8 OCCUPANT SATISFACTION	22
9 RESULTS TO DATE	26
DISTRIBUTION	

TABLES

Number		Page
1	Total Unit/Month Costs	14
2	Unit/Month Costs in First 4 Years, 8 Months	14
3	Increase in M&R Costs	14
4	Painting Costs	15
5	Frequency of Maintenance Actions Since Units Were Occupied	16
6	Component Actions and Work Orders	16
7	Maintenance Actions Performed Per Component	17
8	Average Monthly Electricity Consumption Per Housing Unit	19
9	Average Monthly Gas Consumption Per Housing Unit	20
10	Four-Year Summary of Energy Consumption	21

FIGURE

1	Cost Per Unit Per Month Over Time	15
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**MAY 1984 TO SEPTEMBER 1988 SUMMARY OF
FORT IRWIN, CA, FAMILY HOUSING COMPARISON
TEST: OPERATION AND MAINTENANCE COSTS OF
MANUFACTURED vs. CONVENTIONALLY BUILT UNITS**

1 INTRODUCTION

Background

Congress believes that use of manufactured (factory built) military housing, rather than conventionally built units, will result in lower overall costs, and provide durable housing meeting contemporary housing standards. To verify this belief, Congress directed the Department of Defense (DOD) to construct 200 units of manufactured housing at Fort Irwin, CA, and compare them with similarly designed, conventionally built housing.¹

The manufactured units to be constructed would meet Federal Manufactured Housing Construction and Safety Standards (FMHCSS); however, upgrades in certain criteria would be specified to bring the units into conformance with DOD standards. These areas of concern include net usable floor space, energy efficiency, fire and life safety, and durability of certain materials and components. The study would compare the impact of the modified FMHCSS versus standard DOD criteria, except for the essential criteria listed above.

The study is being conducted during the first 5 years the housing units are occupied; initial occupancy on some units started in February 1983. The study compares 200 two-bedroom manufactured units to 144 two-bedroom, conventionally built units. The conditions and parameters for this test were submitted to Congress and a report of the study results will be submitted at the end of the test.

The data collected address operation and maintenance (O&M) costs and user satisfaction for both types of housing. The study identifies not only the differences, if any, in O&M costs, but also the reasons for the differences and their importance for future construction criteria, construction methods, and occupant satisfaction.

Objective

This report's objective is to summarize the O&M costs and the occupant satisfaction data for both conventionally built and manufactured housing from construction through September 1988. This is the last in a series of interim reports; the final report on the 5-year study will be prepared in October 1989. First year data were reported in

¹Report No. 97-44, *Military Construction Authorization Act* (House of Representatives Committee on Armed Services, 1982), pp 8-9.

USACERL Interim Report (IR) P-85/14,² second year data in USACERL IR P-86/06,³ third year data in USACERL IR P-87/10⁴, and fourth year data in USACERL IR P-88/09⁵.

Approach

The first step was to develop data collection and data analysis procedures. The cost comparisons and analyses for this study were established in USACERL Special Report (SR) P-140, *Fort Irwin Housing Comparison Test*.⁶ The data is collected, summarized, and reported yearly.

Scope

Costs are limited to buildings themselves; sidewalks, driveways, streets, lawns, playgrounds, and utility lines outside the buildings are not included. Also, the replacement costs of refrigerators, dishwashers, kitchen stoves, and utility meters are excluded. Costs for the first 2 years did not include the contractor's overhead and profit.

²R. D. Neathammer, *Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, Interim Report (IR) P-85/14/ADA159740 (U.S. Army Construction Engineering Research Laboratory [USACERL], 1985).

³R. D. Neathammer, *Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-86/06/ADA175995 (USACERL, 1986).

⁴R. D. Neathammer, *Three-Year Summary of Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-87/10/ADA180001 (USACERL, 1987).

⁵R. D. Neathammer, *Four-Year Summary of Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-88/09/ADA190017 (USACERL, 1988).

⁶M. J. O'Connor, *Fort Irwin Housing Comparison Test*, Special Report (SR) P-140/ADA130349 (USACERL, 1983).

2 REVIEW OF TEST PLAN

This section gives a short review of the test plan and the final data analyses. Data is being collected in two areas: O&M costs and occupant satisfaction.

USACERL SR P-140 detailed the cost data collection plan and analysis methods. Four basic questions on costs will be answered:

1. Are the average annual O&M costs significantly different?
2. If different, where are they significantly different?
3. Why do the costs differ?
4. What criteria, design features, etc., need to be changed as a result?

Overall maintenance costs and utility costs will be compared separately. If significant differences are found, it will be important to determine their causes.

In addition to the overall cost comparison, the maintenance costs for major building components will be compared. These comparisons will provide more detail about where and why cost differences occur.

Costs to restore each unit to a comparable level of "new plus fair wear and tear" will be determined at the end of the test period. This will be done under the guidance of the Fort Irwin DEH and the Los Angeles District Office of the Corps of Engineers.

In addition to cost comparisons, occupant satisfaction with the overall apartments and each physical part of the unit will also be compared for the two types of construction. The questions used to determine this factor are given in USACERL IR P-85/14, Appendix F. When occupant satisfaction differs for a building component, that component will be evaluated to determine the reason for the difference.

One maintenance practice may affect the test results and will be accounted for in the final evaluation. No "routine" or "preventive" maintenance was performed through 30 September 1986, although the contractor originally planned to do so. That is, no seasonal maintenance on the heating/cooling systems was done--no periodic filter changes, etc. This may impact the breakdown repairs of these systems. However, the effect should not bias the test, as both type of units were treated the same. "Preventive" maintenance is done when occupants move out; a team inspects the unit and either performs minor maintenance or writes a work order (WO) to have work done. From 30 September 1986 to 30 September 1988, Dynalectron performed scheduled maintenance (called cyclic maintenance). The workers checked all building components and performed needed repairs. The Army did renew this program in FY89.

3 DESCRIPTION OF THE FAMILY HOUSING UNITS

Manufactured Housing Units (MHUs)

These 200 units consist of 50 two-story fourplexes. Each upper unit has a balcony-porch and each lower one has a patio with privacy fencing. Each unit has a refrigerator, gas range, gas water heater, garbage disposal, central air conditioning, and gas-fired forced-air furnace (all provided by the contractor). Each unit has two bedrooms, a kitchen, living-dining area, family room, one bathroom, utility room, and a one-car garage. There are two units on each level.

Initial occupancy was:

61 units	Dec 83
7 units	Jan 84
64 units	Feb 84
57 units	Apr 84
9 units	May 84
2 units	Jun 84

Conventionally Built Units (CBUs)

The 144 units consist of 13 sixplexes, 6 fiveplexes, and 9 fourplexes, all two-story buildings. Each unit has two bedrooms, a kitchen, living-dining area, family room, one bathroom, utility room, either a fenced patio or balcony-porch (for upper unit), and a one-car garage. The fourplexes have two units on each level. There are two units on the second story in the five- and sixplexes with the additional unit(s) on the first level. The CBUs also have a refrigerator, gas range, gas water heater, garbage disposal, central air conditioning, and gas-fired forced-air furnace.

A detailed description of all units can be found in the Los Angeles District Office report.⁷ The buildings were not specifically adapted to the desert environment but are typical Southern California design.

Initial occupancy was:

8 units	Feb 83
28 units	Mar 83
38 units	Apr 83
31 units	May 83
23 units	Jun 83
14 units	Jul 83
2 units	Aug 83

⁷Fort Irwin Family Housing Study—A Report on Manufactured/Factory-Built Housing and Site-Built Housing, Fort Irwin, CA (U.S. Army Corps of Engineers, Los Angeles District, September 1984).

4 DATA COLLECTION PROCEDURES

Data collected in this study and their level of detail are discussed in USACERL SR P-140. That report requires that data be collected at such a level of detail that any differences found between the two types of construction can be explained. Appendix A in IR P-85/14 lists the housing units and their identification numbers used in the data collection.

Data Collection

Discussions were held with the technical monitor, Engineering and Housing Support Center (EHSC) representatives, the FORSCOM HQ representative, Fort Irwin personnel, and representatives of the base operations contractor, Boeing Services International (BSI), to establish the best methods of collecting the data. For O&M data, USACERL designed report forms (Appendix B of IR P-85/14). BSI was contracted to segregate all service orders for maintenance for the test units and report cost data to USACERL through the Fort Irwin Directorate of Engineering and Housing (DEH) on a monthly basis.

BSI was contracted to read gas and electric meters at the end of each month and report similarly.

Self-help data reports* and occupancy data were to be forwarded quarterly.

An occupant satisfaction questionnaire was to be given to each vacating family with a mail-back envelope to USACERL.

A new contractor, Dynalectron, became the base operations contractor effective 1 October 1986. They are performing the same services described above.

Data Verification

USACERL is verifying the reported data several ways. Each WO document is checked against the reported data forwarded by the contractor. Discrepancies are resolved on verification visits to Fort Irwin. Additionally, the contractor has set up separate accounting codes for the two groups of units and the total billed is compared to the total obtained from summing over all the individual WO data.

USACERL developed a computer program to compare monthly readings. When apparently erroneous data occurs, the contractor is notified and corrections are made.

Data Analysis

Maintenance Costs

These costs are reported on a unit-month basis and yearly basis. The data are also summarized by building component to determine if one or more components for one of

*Self-help is a program whereby occupants obtain supplies and materials from a central warehouse to make minor repairs themselves.

the types of units has large maintenance costs. If so, the reasons for these costs will be determined; i.e., what criteria or design features should be reviewed/changed?

Cost differences could be caused by material quality, installation, differences inherent to manufactured or conventional construction, and possible errors in specifications for the two projects.

Warranty work referred to the construction contractor was not included in the cost comparison since no cost data are available or applicable, as it is not a cost to the government. However, the cost of a service call to assess a problem is included.

Energy Consumption

Gas and electricity consumption are reported on a unit-month basis and a yearly basis. Since most of the MHUs were not completed until May 1984, prior energy consumption data for the CBUs will not be used in comparisons. (Energy consumption comparisons are only valid for the same time frame because of varying weather conditions.)

Occupancy Effects

Occupancy data are also being collected. These data are analyzed to ensure that both types of units have a similar distribution of occupants during the 5 years (ages, numbers). If required, these data will be correlated with O&M costs to help explain differences in costs.

Self-Help Data

These data are summarized to see if maintenance costs are affected.

Occupant Satisfaction Survey

Data from the questionnaires are analyzed to determine any differences in satisfaction with the two types of units.

5 WHOLE HOUSE ENERGY TESTS

Three whole-house energy tests were performed immediately upon completion of construction on a sample of units from each type of construction. Appendices C and D of IR P-85/14 give details.

House Tightness

The number of air changes per hour were measured with the following results:

Type	No. Units	Average Air Change Per Hour	Standard Deviation
CBU	15	13.0	1.06
MHU	12	10.9	2.67

There is a statistically significant difference between the two types of construction, with the MHUs being more airtight, on the average.

Furnace Efficiency

The furnace efficiency results were as follows:

Type	No. Units	Average Efficiency (%)	Standard Deviation (%)
CBU	13	66.2	6.24
MHU	16	79.3	3.36

The furnace efficiencies of the MHUs were significantly higher than those of the CBU.

Wall Heat Transfer Characteristics

This parameter was not initially measured for the CBUs because of unfavorable weather during the testing period. This parameter was *calculated* for both types of construction using the designed wall construction. These data are given in Appendices C and D of IR P-85/14 and are summarized below:

Type	No. Units	Average Heat Loss (Btu/hr-°F)	Standard Deviation (Btu/hr-°F)
CBU	16	310	51
MHU	15	237	58

6 OPERATION AND MAINTENANCE (O&M) COSTS

Overall Costs

The total housing unit-months and maintenance costs through September 1988 are shown below in Table 1. (Maintenance includes all types of repairs and "preventive maintenance" performed. See Scope, p 8, for costs excluded from the analysis.)

Table 1

Total Unit/Month Costs

<u>Type</u>	<u>No. Unit Months</u>	<u>Total Cost (\$)</u>	<u>Cost/Unit/ Month (\$)</u>	<u>Cost/Unit/ Year (\$)</u>
MHU	11,020	314,788	28.57	343
CBU	9,439	250,722	26.56	320

Table 1 reflects all data collected through September 1988. However, the CBUs are 10 months older than the MHUs, on the average. So to get a better comparison, the costs for the first 4 years, 8 months for each type are shown in Table 2.

Table 2

Unit/Month Costs in First 4 Years, 8 Months

<u>Type</u>	<u>No. Unit Months</u>	<u>Total Cost (\$)</u>	<u>Cost/Unit/ Month (\$)</u>	<u>Cost/Unit/ Year (\$)</u>
MHU	11,020	314,788	28.57	343
CBU	8,143	174,920	21.48	258

Discussion

There was a large increase in M&R costs during FY88. This is illustrated below in Table 3.

Table 3

Increase in M&R Costs

<u>Date</u>	<u>Total MHU (\$)</u>	<u>Cost/ Unit (\$)</u>	<u>Total CBU (\$)</u>	<u>Cost/ Unit(\$)</u>
Construction - 30 September 1986	104,599	523	107,715	748
1 October 1986 - 30 September 1987	76,611	383	51,431	357
1 October 1987 - 30 September 1988	133,225	666	90,667	630

This is attributable to the increase in interior painting as many units were vacated for the first time or required painting on change of occupancy. See Table 4.

Table 4

Painting Costs

<u>Date</u>	<u>Total MHU (\$)</u>	<u>Cost/Unit (\$)</u>	<u>Total CBU (\$)</u>	<u>Cost/Unit(\$)</u>
Construction - 30 September 1986	5,399	27	9,453	66
1 October 1986 - 30 September 1987	13,870	69	11,988	83
1 October 1987 - 30 September 1988	54,115	271	37,920	263

Costs per unit have been increasing over time. Figure 1 shows the cost/unit/month for ages 12 to 53 months, illustrating this trend.

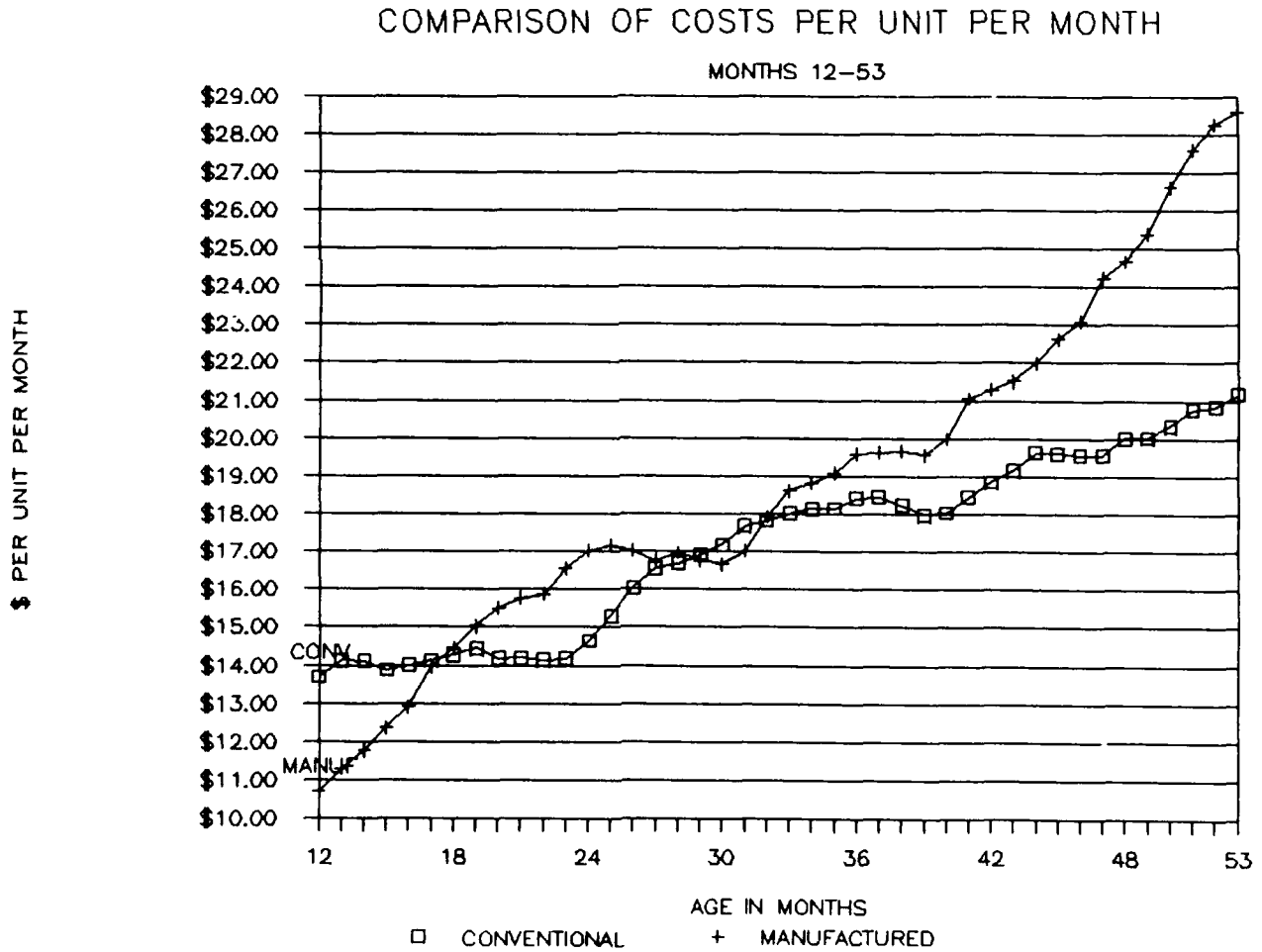


Figure 1. Cost per unit per month over time.

Frequencies of Maintenance Per Housing Unit

For the MHUs, the number of WOs for a housing unit ranges from 5 to 75. For the CBUs, the range is 10 to 77. Table 5 lists the frequencies.

Table 5

Frequency of Maintenance Actions Since Units Were Occupied

<u>MHU</u>		<u>CBU</u>	
<u>No. of WOs</u>	<u>No. of Units With These Totals</u>	<u>No. of WOs</u>	<u>No. of Units With These Totals</u>
90+	8	90+	7
80-89	8	80-89	13
70-79	20	70-79	20
60-69	39	60-69	22
50-59	49	50-59	26
40-49	36	40-49	38
30-39	27	30-39	13
20-29	11	20-29	4
1-19	2	1-19	1

It should be noted that the "number of work orders" is the number of component actions. When a change of occupancy occurs, numerous building components are repaired--there is one official WO number but each component action is considered a WO for analysis purposes. This can be seen in Table 6.

Table 6

Component Actions and Work Orders

<u>Date</u>	<u>MHU</u>			<u>CBU</u>		
	<u>Number Component Actions</u>	<u>Number WOs</u>	<u>Average Number WOs/Unit</u>	<u>Number Component Actions</u>	<u>Number WOs</u>	<u>Average Number WOs/Unit</u>
Start -						
30 September 1984	855	851	4	1,263	1,251	9
1 October 1984 -						
30 September 1985	1,441	1,256	6	1,084	879	6
1 October 1985 -						
30 September 1986	1,767	1,233	6	1,256	818	6
1 October 1986 -						
30 September 1987	3,015	1,560	8	2,068	1,031	7
1 October 1987 -						
30 September 1988	<u>4,040</u>	<u>1,878</u>	<u>9</u>	<u>2,791</u>	<u>1,312</u>	<u>9</u>
Totals	11,118	6,778	33	8,462	5,291	37

Maintenance Per Component

Table 7 lists the frequencies of work orders and costs per building component, where the frequency or cost is at least 2 percent of the total number of WOs or total cost, respectively.

Self-Help Repairs

Total self-help costs to date (not included in the overall costs shown above) are \$467 for MHUs and \$370 for CBUs. (The self-help program was discontinued at the end of FY85.)

Table 7

Maintenance Actions Performed Per Component (Percent of WOs by Component)

Component No.	Description	Maintenance/Repair Actions		Cost (\$)	
		CBU (N=8462)*	MHU (N=11,118)	CBU (Total=250,722)	MHU (Total=314,788)
0101	Roofing Surface	95 (1%)	265 (2%)	7183 (3%)	20097 (6%)
0104	Gutters and Downspouts	190 (2%)	246 (2%)	2522 (1%)	3100 (1%)
0206	Exterior Doors and Frames	301 (4%)	493 (4%)	5698 (2%)	10191 (3%)
0207	Storm and Screen Doors	408 (5%)	453 (4%)	10970 (4%)	14651 (5%)
0209	Storm Windows and Screens	203 (2%)	174 (2%)	3688 (1%)	2784 (1%)
0214	Interior Doors	725 (9%)	745 (7%)	13891 (6%)	10477 (3%)
0217	Kitchen Accessories, Cabinets	131 (2%)	170 (2%)	1807 (1%)	2357 (1%)
0220	Garage Door	389 (5%)	258 (2%)	8068 (3%)	4292 (1%)
0301	Resilient Flooring	---	193 (2%)	---	4178 (1%)
0401	Paint, Walls and Ceilings	411 (2%)	141 (1%)	58342 (23%)	70088 (22%)
0607	Heating Controls	111 (1%)	---	4368 (2%)	---
0608	Other Heating	318 (4%)	437 (4%)	4590 (2%)	5623 (2%)
0702	A/C Motors, Blowers, Pumps	74 (.1%)	---	5310 (2%)	---
0704	A/C Refrigerant	325 (4%)	165 (1%)	12038 (5%)	6296 (2%)
0707	Other Cooling	344 (4%)	373 (3%)	5047 (2%)	5495 (2%)
0801	Water Heater	179 (2%)	284 (3%)	3987 (2%)	9409 (3%)
0803	Piping, Supply	---	252 (2%)	---	8235 (3%)
0804	Faucets and Shower Heads	323 (4%)	728 (7%)	7092 (3%)	14551 (5%)
0805	Lavatories	243 (3%)	419 (4%)	3870 (1%)	9609 (3%)
0806	Water Closets	461 (5%)	643 (6%)	8721 (3%)	12143 (4%)
0807	Bathtub/Shower Unit	---	209 (2%)	---	4140 (1%)
0904	Wall Receptacles	183 (2%)	292 (3%)	2219 (1%)	4055 (1%)
0906	Light Fixtures	685 (8%)	511 (5%)	11556 (5%)	7648 (2%)
1001	Garbage Disposal	215 (3%)	351 (3%)	4347 (2%)	6246 (2%)
1002	Dishwasher	201 (2%)	490 (4%)	7077 (3%)	11757 (4%)
1003	Range	471 (6%)	707 (6%)	11369 (5%)	13443 (4%)
	Total	6855 (81%)	8829 (79%)	201,753 (80%)	258,508 (82%)
	Others (Less) than 2%	1607 (19%)	2289 (21%)	48,969 (20%)	56,280 (18%)

*N = Number of WOs

**--- = Less than 2%.

7 ENERGY COSTS

Comparisons of gas and electricity consumption began in May 1984, since most MHUs were not occupied before then.

Electricity Consumption

The average usage (kWh) per housing unit is shown in Table 8. For the entire 53-months data collection period, an MHU used an average total of 44,180 kWh while a CBU used an average of 40,513 kWh. This is a difference of 667 kWh ÷ 53 months = 12.6 kWh/month. At the September 1988 rate of \$0.0925/kWh an MHU cost \$1.17 more than a CBU for electricity per month.

Gas Consumption

The type of gas used is liquid propane. The average monthly usage (cu ft) per housing unit is shown in Table 9.

For the 53-month period, an MHU used an average total of 81,970 cu ft while a CBU used an average total of 77,990. This is a difference of 3,980 cu ft ÷ 53 months = 75 cu ft/month. At the September 1988 cost of \$0.01849/cu ft an MHU cost \$1.39 more than a CBU for gas per month.

Cost Comparison Summary

For the 4-year period (October 1984 to September 1988) the averages for dwelling unit energy consumption and cost are given in Table 10. The MHU on the average have cost \$20 more per year for gas and electricity.

Comments

The data in Chapter 5 (better air tightness and higher furnace efficiencies for the MHUs) would indicate the MHUs should use less energy than the CBUs. However, detailed energy simulations (performed at USACERL using the Building Loads Analysis and System Thermodynamics program) indicate three design/construction features negate these two measured variables: the MHUs have more window/door glass area; the MHUs have single-pane glass while the CBUs have thermal-pane; and the CBUs are built on a slab (which modulates heating/cooling demands) while the MHUs are built on a crawl space. The final report of this project will give complete details. Meanwhile, no conclusions should be drawn until the 5 year analysis is completed.

At the end of the study, energy consumptions of individual units will be compared. Any units with extremely high consumptions over several occupants will be checked to try to determine the cause.

Table 8

Average Monthly Electricity Consumption (kWh) Per Housing Unit

	1985												Monthly Avg	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Year 1	MHU	780	1007	1218	1263	1001	557	445	486	484	427	423	633	727
	CBU	704	959	1170	1132	907	582	433	471	463	417	444	549	687
	1986												Monthly Avg	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Year 2	MHU	679	1179	1451	1420	643	574	525	514	507	447	465	468	740
	CBU	661	1013	1425	1312	700	610	547	492	482	434	465	484	719
	1987												Monthly Avg	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Year 3	MHU	828	1148	1280	1520	746	572	460	571	500	429	474	592	760
	CBU	789	1070	1270	1335	857	633	451	607	570	512	492	646	767
	1988												Monthly Avg	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Year 4	MHU	665	1038	1174	1460	1035	679	503	520	476	487	464	470	743
	CBU	674	1060	1282	1247	1142	755	568	515	494	485	520	476	761
	1988												Monthly Avg	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Year 5	MHU	766	969	1336	1438	1023								
	CBU	771	885	1227	1406	1040								

Table 9

Average Monthly Gas Consumption (cu ft) Per Housing Unit

	1985												Monthly AVG
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Year 1	MHU	900	680	570	620	580	1410	2400	3560	3540	2700	1460	1787
	CBU	710	640	530	590	530	1110	2070	3180	3220	2390	1270	1591
	1986												Monthly AVG
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Year 2	MHU	960	610	620	660	700	1050	2670	2840	2540	1700	1380	1504
	CBU	820	570	580	670	650	880	2410	2560	2400	1680	1360	1398
	1987												Monthly AVG
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Year 3	MHU	910	560	600	610	840	1210	1750	3320	3390	2510	1070	1623
	CBU	890	650	730	720	830	1110	1580	3090	3310	2530	1160	1612
	1988												Monthly AVG
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Year 4	MHU	800	660	630	620	600	680	2020	3920	3320	2040	1460	1621
	CBU	800	790	690	670	640	670	2080	3400	3320	1980	1330	1594
	1988												Monthly AVG
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Year 5	MHU	124	68	56	64	66							
	CBU	112	66	62	68	68							

Table 10

Four-Year Summary of Energy Consumption

<u>Unit</u>	<u>MHU</u>		<u>CBU</u>	
	<u>Gas</u>	<u>Electricity</u>	<u>Gas</u>	<u>Electricity</u>
Average Consumption/Year Per Housing Unit	19,701 cu ft	8,978 kWh	18,769 cu ft	8,907 kWh
Average Cost/Year Per Housing Unit	\$364	\$830	\$347	\$824

8 OCCUPANT SATISFACTION

One part of the study assesses occupants' satisfaction with their housing. The use of lower cost housing for Army personnel would not be cost effective if it created morale problems or lower reenlistment rates. A questionnaire developed at USACERL and approved by FORSCOM, EHSC, and HQUSACE is given in Appendix F of IR P-85/14.

A copy of the questionnaire with a mail-back envelope (to USACERL) is given to each vacating family by the contractor approximately 2 weeks before they leave. The family is encouraged to complete and mail it back when they vacate.

Through September 1988, 347 of 912 vacating occupants (38 percent) returned questionnaires. This response rate is considered low. Special surveys were done in September 1984, April 1985, and June 1986 of all families who had lived in their quarters at least 1 year. Of these, 122 (52 percent) returned questionnaires.

For analysis purposes, only occupants who had lived in their quarters for at least 12 months were considered, since they would have been through both heating and cooling seasons.

The responses from occupants of the two types of units were compared by performing cross tabulations. The following paragraphs show results for key questions and for questions for which occupants of the two housing types differed significantly (95 percent confidence). There were 179 responses from occupants of CBU and 190 for MHU.

Q5. How would you rate the condition of your quarters?

	Excellent	Better than Average	Average	Below Average	Poor
CBU	25%	42	32	1	0
MHU	20	42	33	5	0

No statistically significant difference was found in responses between occupants of the two housing types.

Q6. In general, how satisfied have you been with these quarters?

	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
CBU	31%	59	8	2
MHU	29	59	12	0

No significant difference was found.

Q7E. In general, are you satisfied with your kitchen cabinets?

	Satisfied	Not Satisfied	No Opinion
CBU	76%	22	2
MHU	91	9	0

There was a difference between CBU and MHU occupants.

Q7J. In general, are you satisfied with living/dining room floors?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	63%	34	3
CBU Second Floor	90	9	1
MHU First Floor	64	34	2
MHU Second Floor	77	20	3

There was a statistically significant difference between first and second floor occupants of the two housing types. Second floor units have carpet while first floor units have tile/vinyl. Second floor occupants were more satisfied.

Q7J1. How would you rate cleanability of living/dining room floors?

	Easy to Clean	Hard to Clean	No Opinion
CBU First Floor	58%	36	6
CBU Second Floor	76	11	13
MHU First Floor	71	21	8
MHU Second Floor	57	25	18

There was a statistically significant difference between occupants of CBU and MHU for cleanability of living/dining room floors, caused by the CBU first floor occupants' responses.

Q7K. In general, are you satisfied with the bedroom floors?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	71%	28	1
CBU Second Floor	97	0	3
MHU First Floor	70	28	2
MHU Second Floor	82	16	2

There was a statistically significant difference: second floor (carpet) occupants were more satisfied.

Q7K1. How would you rate cleanability of bedroom floors?

	Easy to Clean	Hard to Clean	No Opinion
CBU First Floor	65%	31	4
CBU Second Floor	76	11	13
MHU First Floor	73	19	8
MHU Second Floor	66	16	18

There was a statistically significant difference between first floor and second floor occupants for cleanability of bedroom floors with more first floor occupants (vinyl/tile) rating it as hard to clean.

Q7M. In general, are you satisfied with the interior walls?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	56%	43	1
CBU Second Floor	73	24	3
MHU First Floor	72	26	2
MHU Second Floor	77	20	3

There was a statistically significant difference: more dissatisfaction was shown by CBU first floor occupants.

Q7M1. How would you rate the cleanability of the interior walls?

	Easy to Clean	Hard to Clean	No Opinion
CBU	48%	42	10
MHU	57	29	14

There was a statistically significant difference: the CBU occupants rated walls as harder to clean.

Q9-10. There was no difference between CBU and MHU for noise/odor annoyance from other quarters.

Q15. Please list three things about your apartment you like most.

Of 828 items listed:

Dishwasher	- 10%	Separate laundry room	- 10%
Garage	- 9%	Kitchen arrangement	- 6%
Air Conditioner	- 8%	Design	- 5%
Roominess	- 8%		

Q16. Please list three things about your apartment you do not like.

Of 609 items listed the following were listed most frequently:

Floors	- 10%	Bathroom too small	- 4%
Neighbors' noise	- 6%	Cheap construction	- 3%
Thin walls	- 5%	Cheap carpeting	- 3%
Sprinklers	- 4%		

Q17. Please make any general comments about your apartment:

Of 159 comments these occurred frequently:

Satisfied with apartment	- 35%
Very satisfied with apartment	- 30%
Cheap construction	- 14%

9 RESULTS TO DATE

This interim report has summarized the O&M costs and occupant satisfaction data collected for conventionally built and manufactured housing units at Fort Irwin, CA. The data cover a 5-year period from construction through September 1988. Through the first 4 years, 8 months of occupancy there is a 33 percent (\$85) difference per unit in yearly maintenance and repair costs between the two types of units (MHU have higher costs). For 4 years energy costs the MHU are higher than for the CBU (about \$23/year per unit); and occupants of the two types of units are equally satisfied with their apartments.

Through September 1988 the occupancy rates for the two groups are very similar: CBU, 98.0 percent; and MHU, 97.8 percent.

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