Performance of Alaska Craftsman Homes: One Year of the Real World

Richard D. Seifert, University of Alaska Fairbanks, and the Alaska Craftsman Home Program

The Alaska Craftsman Home Program (ACHP) began in March of 1987. It was conceived as an educational program aimed at improving the quality, energy efficiency and marketing of homes specifically designed to survive the Alaskan climates. The program has developed a full technical residential specification, a building manual, an educational program, and a network of educated builders and homeowners. Homes built to the specification of ACHP follow strict stipulations; air leakage is tightly controlled, insulation levels are climatically determined, and mechanical ventilation is required. These specifications are ensured by a blower door test for air-tightness, and a ventilation certification program.

After five years of marketing and educational efforts, a survey of homeowners and a monitoring effort to measure the performance of the certified homes is reported. A condensation of the survey results is also included to encompass some of the more subjective responses to the performance of the ACHP homes and their perceived advantages and disadvantages. Two types of information were utilized in assembling this comparative study:

1. A homeowner survey was employed to measure attitudinal responses to the home, level of satisfaction of the occupants, and modes of use of the home.

2. A direct monitoring of all utility energy consumption was obtained from utility billing records, and the actual use compared to that predicted in the original HOT2000 simulation.

Introduction

The Alaska Craftsman Home Program (ACHP) is a unique cooperative venture in promoting energy efficiency and educating Alaskans about the appropriate techniques for building residential structures in the wide range of severe climates in Alaska. In 1987 when the program was established, it was clear that Alaskans needed an educational network to keep the building industry and its customers informed of advances in other parts of the world.

ACHP has been that network and has also evolved into a widely accepted source of state-of-the-art building information for cold climates. ACHP began its life as a cooperative effort of both Public and private forces. The original incorporators of the idea were the University of Alaska Cooperative Extension Service, the Alaska Department of Community and Regional Affairs-Energy Division, Energy Rated Homes of Alaska, and the critical private sector participation from the Alaska State Homebuilder's Association. This uniquely forged alliance proved to be durable and fertile, and a non-profit educational corporation, ACHP, Inc., was formed in 1990 to carry forward with the mission of the original volunteer effort. As a result of ACHP, the information network is firmly established in Alaska, and Alaskans are now more aware than ever before that they can live in durable, affordable, comfortable, and healthy homes and can benefit economically from these improvements in the shelter industry.

With the attempt to raise the quality of housing in Alaska came the need to set a level of quality assurance, to ensure that quality was built into homes. To accomplish this, the ACHP enlisted a technical advisory committee of volunteers to establish a set of performance specifications to enable houses to be certified. This has been done for three years, and although it is often a long process, certification has resulted in registry of 27 homes as of January, 1992.

ACHP utilizes a Building Manual as its main encyclopedia of building information. The program also publishes a

bi-monthly newsletter of housing technology entitled Northern Building Science, which provides updated information on building techniques to people who have taken the 2-day educational workshop. These educated builders receive a year's subscription as part of the workshop benefits. ACHP provides this workshop as part of educational requirements for contractor licensing. This new responsibility has only been in effect since 1991, and it has kept the demand steady for the workshop and education, and has given the program wide exposure in the building industry.

Although the 1987-90 period was an abysmal slump in new housing starts, the market has improved substantially in the past year. The slump was a major factor in the slow adoption of the ACHP model for housing construction. And, consequently a track record for the "real world" performance of ACHP certified homes has been slow to emerge. But, nothing makes a case for a housing system which incorporates energy efficiency better than a real-world track record. So for the past three years, ACHP has steadily increased the number of certified homes, so that a proven track record of their performance could be established. Although homes have been certified in most of the climatic zones in Alaska, as of January 1992, only 20 have been occupied for more than a year and therefore have a heating season of data available. (See Figure 1 for Alaska locator map). These 20 homes define the sample for this study.

The certification process of the Alaska Craftsman Program Home Program deserves some special attention, because it is rigorous and allows for quality control in the airtightness and ventilation system of the home. Through blower door testing, inspection of the air-vapor barrier of the home during construction, and certification of the ventilation system, the structural integrity is ensured and mechanical ventilation guaranteed. The "technical specifications," as they are called, are spelled out in considerable detail in the first appendix of the Alaska Craftsman Home Building Manual (Appendix A ,1988, second edition). This manual serves as the technical reference and teaching resource in the educational courses delivered through the program. Using the manual and educational workshop as the technical basis of the certification specifications, ACHP has established a very high standard

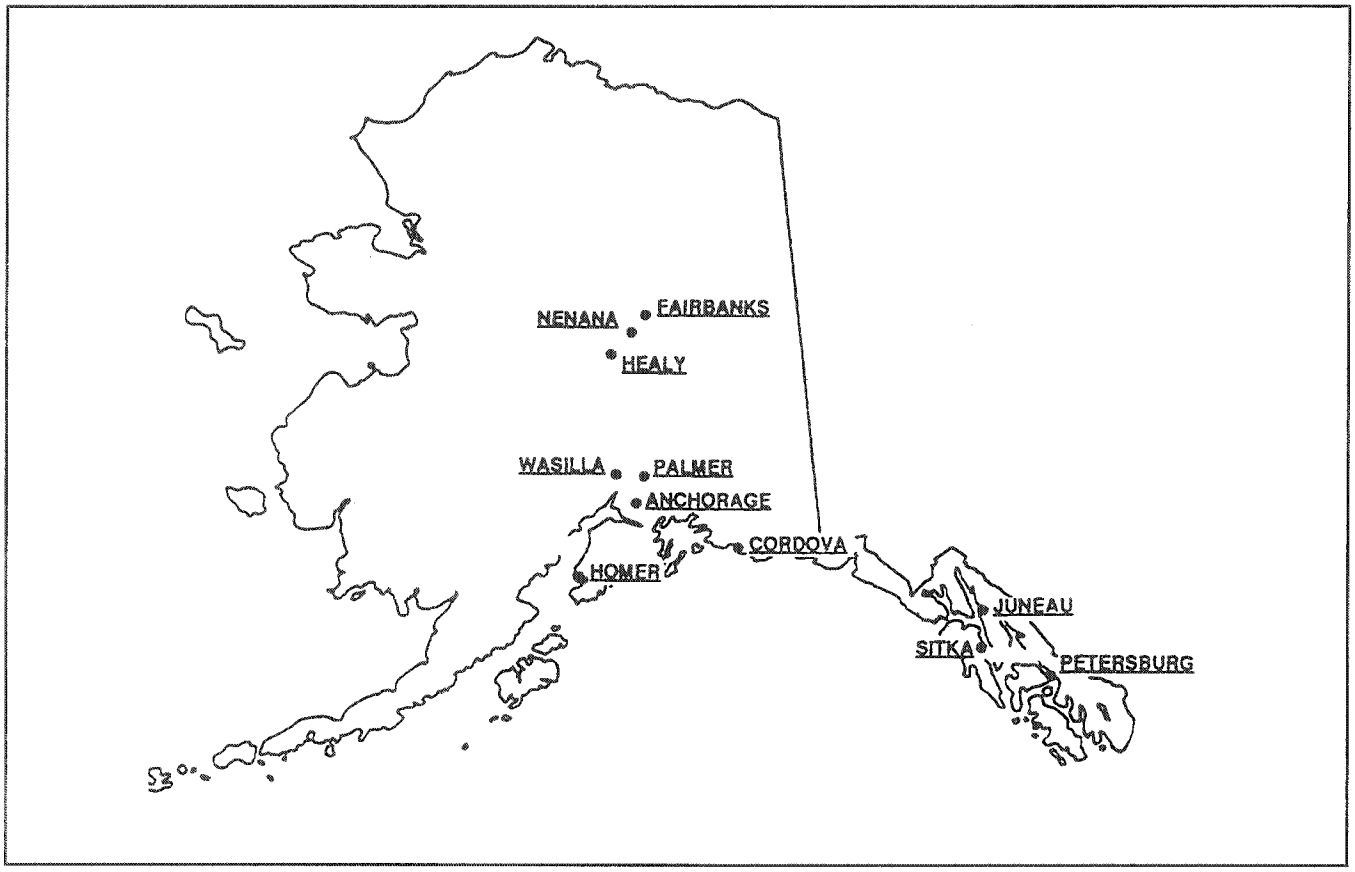

Figure 1. Locator Map - ACHP Homes in Alaska

of construction quality, and has educated more than 2500 Alaskans, leading the way in establishing state-of-the-art building techniques and technical awareness in Alaska. Five elements are central to the ACHP home building system. They are:

- High levels of thermal insulation, especially a high integrity thermal envelope, which ensures lower heating demands and lowers the resultant resource use and pollution of the environment.

- Continuous air-vapor retarders are a critical construction item in Alaska, where controlling air leakage is essential to comfort and the control of moisture transport into and through the building envelope.

- Continuous fresh air, delivered through controlled mechanical ventilation is required in ACHP homes. This improves indoor air quality and helps maintain the health of the occupants.

- The encouraged use of high quality building products appropriate to the residential application and climate.

- ACHP Homes incorporate environmental determinants (homes are regionally "tuned" by computer simulation) and meet all local code and life safety requirements.

Research Approach

This study uses the ACHP certification process, along with a written survey of homeowners as the major data sources. ACHP certification employs a pre-construction design tool, the HOT2000 computer program developed in the Canadian R-2000 program, to test an entire set of building specifications, size the heating system, specify options for insulation levels and windows, and so on. HOT2000 uses an integrated thermal envelope heat loss target based on local heating degree-days and site conditions (such as basement and soil types), to evaluate the design and predict its thermal performance before it is built. The result is that each certified ACHP home has a predicted, computer-simulated performance which was calculated before construction, and which is used as a predictor for the energy use of the "as-built" house.

This study uses these HOT2000 runs as the predicted performance for ACHP homes. In order to determine the actual heating and total energy use in the homes, a detailed survey was sent to each ACHP homeowner. The survey form was aimed at getting a marketing database and testimonials, as well as energy and utility consumption data. In each case, records of actual utility bills were sought. The survey also contains data which give a good indication of occupancy and utilization patterns. These can radically affect energy consumption, and are utilized to interpret any performance data questions which arose. By interpreting the surveys and actual energy use of the houses, a validation of the HOT2000 program is also possible. For marketing and credibility concerns, it is deemed very important by ACHP, Inc. to determine to what extent the HOT2000 program is a good predictor of actual energy use and costs, and where it may have consistent flaws or weaknesses. The results of the validation of HOT2000 are reported.

Normalization of the heating degree-day data was necessary in the development of this analysis. It was accomplished by a direct comparison to data available from the National Climatic Center (NCC, 1989-91) for the locations of the homes in the ACHP study group. Since the PRISM method was not available to the author in time to use for this analysis, a more simplistic annual ratio method was used. The annual heating degree-day (HDD) sum for the given year of interest was simply divided by the long term average HDD for the period of record at the site. Normalization of performance comparisons were then accomplished in the following way: The normalized ratio of heating degree-days calculated as described above, was used to correlate the actual total energy used by dividing the total energy use by the normalization factor. This puts the actual energy use in a form which enables it to be compared to the predicted energy use as calculated by HOT2000. The normalization also accounts for variability in heating energy use in any given year as a result of that year being proportionally colder or warmer than the long term "average year", indicated by the average HDD value.

In all cases in this study, the years of record (1989, 1990, and 1991) were each warmer years than average in the locations of the certified homes. In addition, some homes were modelled with HOT2000 using the climatic data from a city different from the actual location, because the climatic data for the given location was not part of the HOT2000 data file. This caused a rather peculiar difficulty for the normalization of weather data. The use of an alternative weather data file occurred for many locations: Sitka was modeled with Kodiak data, Healy and Nenana with Fairbanks data, Petersburg with Juneau data, Anchorage and Wasilla with Palmer data, and Cordova with Yakutat data. A total of nine of the homes in the sample required this doubly complex readjustment of the normalized climatic data because of this lack of local data in the HOT2000 program. However credible results are achieved in the normalization because the National

Climatic Center (1989-91) publishes heating degree-day data for all the home locations, by month. This is the information used in this study to "clean up" and normalize the climatic data for the performance comparison.

The Sample

A list of the surveyed ACHP homes is given in Table 1. The file number is the sequential ACHP registration number, and the city where the home is located is given along with the zip code. In addition, Figure 2 shows, in the form of a histogram, the comparison of the predicted energy use for the sample of 13 ACHP homes, to the actual energy use for at least one year of record.

Sample Attrition

For only 13 of the 20 certified homes (with more than one year of residency) do we now have either performance (typically actual utility billings) data or a fully reported homeowner survey, from which the performance data can be obtained. This attrition is mainly due to the short

Table 1. ACHP Certified Homes

File #	City Location	State	Zip
89-01	Wasilla	AK	99654
89-02	Wasilla	AK	99654
90-01	Fairbanks	AK	99709
90-02	Homer	AK	99603
90-03	Palmer	AK	99645
90-04	Juneau	AK	99803
90-05	Anchor Point	AK	99556
90-06	Healy	AK	99743
90-07	Palmer	AK	99645
90-09	Homer	AK	99603
90-10	Nenana	AK	99760
90-11	Anchorage	AK	99515
90-12	Whitehorse	Yukon	Y1 A422
90-13	Kenai	AK	99611
91-001	Sitka	AK	99835
91-002	Sitka	AK	99835
91-003	Juneau	AK	99801
91-004	Petersburg	AK	99833
91-005	Anchorage	AK	99502
91-006	Juneau	AK	99801
91-007	Sitka	AK	99835
91-008	Juneau	AK	99801
91-009	Homer	AK	99603
91-010	Cordova	AK	99574
92-003	Sitka	AK	99835
92-004	Soldotna	AK	99669
92-005	Ninilchik	AK	99639

duration of occupancy for many of the ACHP homes in the original sample of 20, or the inability to obtain reliable performance data from the owner or occupant.

Discussion of the Data

Comparisons of the actual and predicted total energy use of thirteen homes are tabulated in Figure 2. There are many complicating elements of this study, which lead to the need for considerable discussion and interpretation. The largest discrepancy between the predicted and actual energy use in a certified home occurred in the first home to be certified, 89-01. The difference was huge: the home used 219% of the predicted energy use in the first year of operation. However, as the first house built to ACHP specifications, it was unique in two ways: first, it was built by a high school carpentry trades class, second, its operation was radically different from the anticipated typical family use, as it was used as a commercial automotive painting shop on weekends during which the attached garage was left open to the Alaskan winter for required ventilation.

For a majority of the homes in this sample the actual energy use exceeded the use predicted by the HOT2000 simulation. There were eight such homes in all, seven in addition to 89-01, described above. The mean percentage by which the actual use exceeded the prediction was 75%, while the range was 7.2%-219%. For the five cases where the use was actually less than the HOT2000 prediction, the range was 6-50%. Since there were only five cases it is not valid to draw a mean. Both these ranges are instructive, because it is unlikely that a climatic data normalization would account for more than a 10%

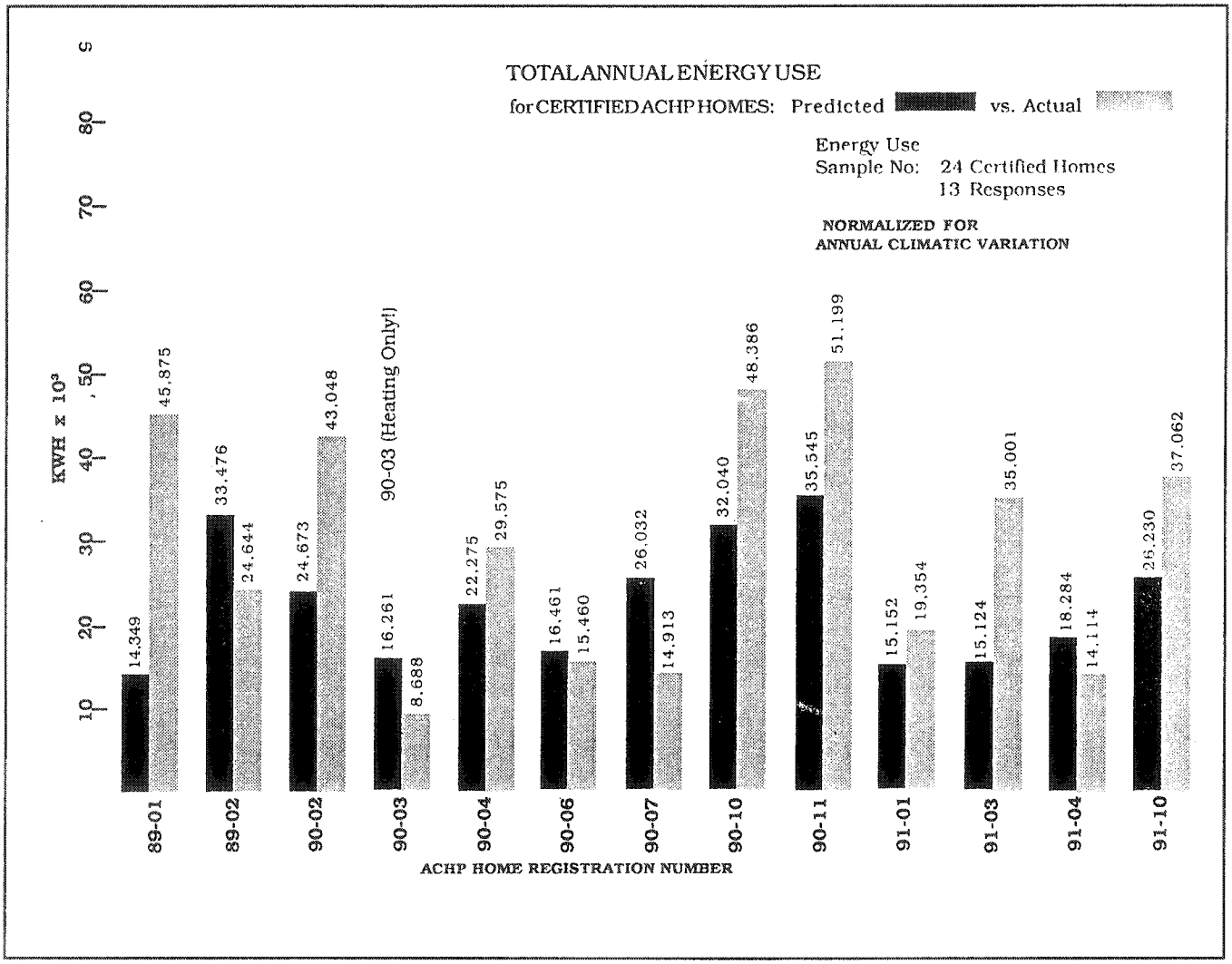

Figure 2. Total Annual Energy Use

variation in these comparisons, and all but two of the deviations from the prediction are greater than 10%. In the set of homes which used less than the predicted energy, all were fairly closely grouped. While it is difficult to get a true trend from such a small data set, it does seem that the variations from the HOT2000 prediction are either 35 percent high or 35 percent low. Clearly the HOT2000 prediction is not very accurate in predicting the actual energy use, and this realization bears some detailed further discussion.

A review of the typical set of conditions entered in the HOT2000 computer simulation is a good place to begin a search for the weaknesses in the simulation as a predictor. A simulation is only as good as the input data. One clear trend in reviewing the data for actual energy use, is that the electrical energy use is the greatest variable in the total end use of energy. And here is also a clear cause of the poor correlation between actual and predicted energy use. The standard value for daily electrical energy use is consistently used in the simulation (this is not the default value, but it is used in the same way), 16 kwh/day. This is a national average number and is reasonable, but clearly does not reflect the different results in the real ACHP homes. For the homes in Southeast Alaska, (Petersburg, Juneau, and Sitka), where hydroelectricity is available and the energy of choice, the electrical use is clearly well predicted by this number. These homes also don't have engine block heaters or as many "predominantly winter use" electrical appliances and demands as homes in other areas of the state. The homes in this group have a performance within 20-30% of the predicted energy use (90-04, 91-01, 91-04, 91-10). In other areas of the state, the reasons for the variation are as variable as the houses. One positive correlation with energy use is the market cost of the home: the more expensive the home, the more likely it is that the actual energy use will exceed the predicted use. House 90-02 fits this category, and its cost was $225,000. It has amenities like a Jen-air kitchen ventilation system, central vacuum cleaning system, and a whirlpool hot tub, and its energy use was 74% above the prediction. House 90-11 also fits this mold, and was a speculative house built in Anchorage and is in the same price range. It has a fireplace and upscale amenities, and it's energy use was 44% above the prediction. While this is not surprising it is also true that these homeowners are also very satisfied with their homes. A comment from an ACHP certified homeowner is reflective of this typically positive response to ACHP homes, "Our home is yielding approximately the same rate of return as a taxable money market fund, but I don't have to pay taxes on the energy savings, as the savings are avoided after tax expenses". Obviously there are some very sophisticated and discriminating ACHP homeowners whose rationale for their purchase is complex and often unique. This Anchorage homeowner has a home in the $300,000 range. All of the certified homes except 90-11(previously noted as a spec home), are custom homes and one-of-a-kind. Although this is not necessarily the road to broad acceptance, it continues to be the dominant characteristic of new ACHP homes, and of the Alaska market generally.

Equally interesting is a closer look at the certified homes which actually used less than the predicted energy. These include 89-02, 90-03, 90-07 (all Wasilla), 90-06 (Healy), and 91-004 (Petersburg). Home 89-02 is one of the first ACHP homes and is characteristic of the group in that these homeowners are all highly motivated and energy-conscious, and wanted to have the best available housing they could afford to build. Home 90-03 is one of only two owner-built houses in the group. This home had no records available for the electrical use, but a comparison of the heating energy use was made, and on that comparison only, this house used 50 % of the predicted energy for heating. A closer look at the total energy use of this home may bring it closer in line with HOT2000 predictions as it has a block heater for an automobile, a hot tub, well pump, and other electrical amenities.

House 90-06 is in Healy, Alaska, where one of Alaska's most active coal mining industries operates. The owner of this house is employed by the coal mining company, and heats with coal which he brings home by pick-up truck. While the accuracy of the amount of coal the family used is always in question, the owner does measure it and the estimate is used in the heating calculation. This home comes very close to the predicted energy use: under by 6%. The coal heating system is an airtight stove. This family also is very frugal and energy conscious, and have some of the most energy efficient appliances available, including a Sunfrost refrigerator. A factor in their energy planning for the home was that they were not on the electrical grid for the first several months of occupancy, but now are. This may influence their energy use in the future.

The final house in the set which used less than the predicted energy use was located in Petersburg, Alaska, a fishing-based community on Mitkof Island in Southeast, Alaska. The family's main livelihood is commercial fishing, and the personal motivation and lifestyle of the owners was a major factor in their adoption of the ACHP home as a goal.

There are also some very unique homes for which the data is compiled. For instance, home 90-07 is a retrofit house, and is predominantly heated with wood. Wood is notoriously difficult to estimate as a heating fuel because the efficiency of the wood stove is unknown.

In 1989, at a conference on energy efficient buildings, Lawton (1989) reported on the homeowner survey work which was done in Canada for the R-2000 program. The R-2000 program has many characteristics and programmatic goals similar to the Alaska Craftsman Home Program. Follow-up surveys from 198 R-2000 homeowners who had occupied their homes for more than one year were analyzed and the results reported. The results provide an interesting comparison with the results of the ACHP homeowner survey done as part of this study.

The most striking revelation about the ACHP homes is the overwhelmingly positive endorsement the homes receive from their owners and occupants. In no case in the surveys returned did the occupant negatively condemn the house. And the homes which performed with greater energy use than predicted were not criticized at all due to this shortcoming. Most Alaskan buyers are so used to huge energy bills and high energy consumption in their homes, that a 30% increase in the predicted use is still so much better than the standard home that they are hardly noticing this shortcoming.

Homeowner Survey Response Comparisons: R-2000 vs ACHP

Who Bought R-2000?	Who Bought ACHP?
The homeowner was predominantly between the ages of 31 and 45 years	12 of 15 homeowners were between 31 and 45 years
Almost half of the homes had two adults and children, while one third of the homes were occupied by childless couples	12 of 15 homes had two adults and children. Two homes were occupied by single adults
The majority of homeowners were employed as "professionals"	5 homeowners were "professionals", 5 were tradespersons, 5 were other
57% of households had two earners	60% of households had two earners
Most homeowners had previously owned a detached home	60% of homeowners had previously owned a detached home
What are the Homeowners' Perceptions After Living in Their	
R-2000 Home?	**ACHP Home?**
The three most important advantages to living in an R-2000 house were: fresh air, quiet, and no drafts	ACHP homeowners felt that fresh air, no drafts, and less dust were the three greatest advantages
The most commonly reported disadvantages were HRV noise, dry air, and high electrical costs	ACHP homeowners reported the exact same disadvantages, and in the same order
Relatively few home-owners specified any indoor air quality problems (<15%)	Only one of 15 homeowners reported a moisture problem
How did the Homeowner Operate the Air Distribution System?	
In R-2000 Homes	**In ACHP Homes**
More than 90% of the homeowners operated their HRVs continuously during the winter	80% of ACHP homeowners operated their HRVs continuously during winter, and 20% operated them discontinuously during the summer
Overall Satisfaction with the Home	
More than 80% of the home-owners responded that they would purchase an R-2000 home again, while less than 7% indicated that they would not	ACHP homeowners unanimously said they would consider ACHP when they purchased another home

So, if the marketing question is, "Do the ACHP homes deliver what they promise?", the answer is, "Not quite." But if the questions include," Are the homes of high quality?", "Do they command a good market price?", and "Do they result in satisfied customers and good publicity?", then the answer is a resounding "Most definitely!" The ventilation requirement for ACHP homes is also probed with the survey. An ACHP homeowner in Sitka, where it is characteristically cool in the midst of a humid temperate rainforest, stated, "The HRV system has made living in Southeast Alaska a possibility...otherwise there would be too much mold and mildew accumulation, especially in the summer months." Another owner from Cordova (also a humid rainforest climate in Prince William Sound) comments: "My wife was diagnosed with 'Sport's Asthma,' and prescribed expensive medication. Once we moved into our ACHP home, all her symptoms disappeared."

Clearly there are both tangible and often intangible benefits from mechanical ventilation which are only beginning to get a test and acceptance in the world of residential housing technology.

Acknowledgments

This paper was made possible through the generous support of the Alaska Craftsman Home Program, which provided both funds and data records. The report would obviously not have been possible without the willing, enthusiastic support of ACHP homeowners. Also the Cooperative Extension Service, University of Alaska Fairbanks provided essential support and facilities for the research. It is also the source of the original concept of an Alaska Craftsman Home Education Program to improve the quality, durability and energy efficiency of Alaskan's homes. Thanks also to Dwight Pollard, Acting State Climatologist for the state of Alaska, who obtained the heating degree day data for this study.

References

Alaska Craftsman Homebuilding Manual, 2nd Edition, 1988 Cooperative Extension Service, UAF, and Alaska Craftsman Home Program, 530 pp. plus appendices.

ACHP Homeowner Surveys, January-April, 1992, unpublished data.

ACHP. Inc. Certified Home files.

HOT2000 User's Manual, Canadian Homebuilder's Association, 1989.

Lawton, Mark D. (1989) Results of the R-2000 Homeowner Survey, in *Proceedings, Excellence in Housing '89*, Seventh Annual International Energy Efficient Building Conference and Exposition, Winnipeg, Manitoba, Canada, March 3-4, 1989, pp E11-E15.

NOAA, Climatological Data-Alaska, 1988-1989, 1989-1990, 1990-1991.

Seifert, R.D., (1989), The Alaska Craftsman Home Program: A Two Year Report, in *Proceedings, Excellence in Housing '89*, Seventh Annual International Energy Efficient Building Conference and Exposition, Winnipeg, Manitoba, Canada, March 3-4, 1989, pp E17-E28.