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Executive Summary

Building America in Alaska II (BAAII) is a special project funded by the US Department of Energy (DOE) and the Alaska Housing Finance Corporation (AHFC) to provide financial support to the Cold Climate Housing Research Center (CCHRC) to conduct research on energy efficiency and cold climate building techniques in Alaska and to promote BAA to builders and the general public in Alaska.

The results of these research efforts have been incorporated into a four-hour course on Building America II approaches to residential construction. Elements of this course have also been introduced into the current 16-hour Cold Climate Homebuilder's class given to general contractors for their residential endorsement.

CCHRC personnel attended Home Shows in Anchorage, Fairbanks, Juneau, and Ketchikan in February and March 2004. CCHRC staff manned a booth at each Home Show and displayed posters, photos, and architectural details of BA homes in Alaska. We distributed US Department of Energy Building America brochures and CCHRC informational packets describing BAAII. In Anchorage we were interviewed by a local TV personality at the Home Show. This footage was edited into a 1-2 minute production that was broadcast during the weekend of the Home Show and for the next five days. We talked to hundreds of folks interested in the latest BAA building techniques for their location in Alaska. Over 10,000 people passed through the Anchorage Home Show and over 8,000 attended in Fairbanks. Several hundred people visited the Juneau and Ketchikan Home Shows. These efforts to promote BAA were written up in quarterly reports and newsletters distributed to members of CCHRC statewide and to the Interior Alaska Building Association.[1]

There was considerable interest at all four Home Shows in the ongoing Building America research at the Mobile Test Lab (MTL) in Juneau. Students and staff at the University of Alaska Southeast Construction Technology Program were able to compile some very interesting preliminary data recorded at the MTL indicating that most conventional wall systems do not perform well in a temperate rain forest environment. Of the nine walls tested only one showed a drying trend over time.[2] The REMOTE wall system (Residential Exterior Membrane Outside-insulation TEchnique) was the only wall that showed a steady drying trend. All other wall configurations increased in moisture content. The REMOTE wall system is being monitored in homes built recently in Fairbanks and Juneau.[3]

After reviewing the results of monitoring various wall types and the outstanding performance of the REMOTE wall system, the CCHRC Southeast Research Advisory Committee has advised the principal investigator at UAS to construct and monitor several different configurations of REMOTE walls in the Mobile Test Lab. These results will be

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[1] Appendix A CCHRC Quarterly Reports & Interior Alaska Building Association Newsletters
[2] Appendix B Monitoring of Wall Drying Characteristics in a Temperate Rainforest Environment, Marquam George, 2004.
[3] ibid

posted on the CCHRC web site and distributed by newsletters to Alaskan builders statewide. CCHRC has created two-hour and four-hour classes for builders based on the latest experience with the REMOTE building system. A REMOTE wall class was presented at the annual convention of the Alaska State Homebuilding Association on October 29, 2004 in Homer, Alaska. A two-hour BAAII class was also presented at the convention in Homer. BAAII power point presentations have been given by CCHRC in the past year to builders and housing authorities in Alaska, Canada, and the lower 48.[4]

CCHRC has made presentations of BAAII to the Association of Alaska Housing Authorities and also to housing authority staff in programs sponsored by the Alaska Office of Native American Programs (ONAP). CCHRC has worked closely with the Interior Regional Housing Authority to provide oversight on several BAAII type homes under construction in the Fairbanks area. The Tlingit-Haida Regional Housing Authority (T-HRHA) has benefited greatly from the Building America Program in Juneau, Alaska. They have been working closely with the UAS Professor of Construction Technology to develop BAAII building techniques that research indicates will work in a Southeast Alaska Rainforest. The Tlingit-Haida Regional Housing Authority used the REMOTE wall building system to construct several homes and apartment buildings. The T-HRHA has collaborated with the UAS Construction Technology staff to develop a low cost ventilation strategy with a simple in-line fan delivering filtered fresh air to occupied rooms in balance with a mechanical exhaust air system.[5]

Introduction to Building America in Alaska

The Cold Climate Housing Research Center contracted with the US Department of Energy and the Alaska Housing Finance Corporation in the year 2000 to promote Building America in Alaska (BAA) through education and research in the design and construction of safe, healthy, energy efficient, durable, and affordable homes in Alaska. In 2001 a team of Alaskan building industry professionals collaborated with Building Science Corporation consortium leader Joe Lstiburek to design three regionally appropriate low-moderate income home designs.[6] The three major climatic regions in Alaska range from a temperate rain forest in Southeast Alaska with about 7,000 heating degree days through South Central with about 11,000 heating HDD to the Interior with over 14,000 HDD. These BAA homes were readily accepted in the Alaska market place and in most cases were sold before completion. Builders in each region expressed an interest in building similar homes in 2002. The Board of Directors at CCHRC were pleased with the experience with Building America in Alaska and recommended that the President/CEO write a proposal to DOE to continue building on the success of this program.

[4] Appendix C DVD on REMOTE and BAAII
[5] ibid
[6] See Building America in Alaska final report October 30, 2001

Building America in Alaska II

In 2002 CCHRC and AHFC proposed to DOE to follow-up on the Building America in Alaska program with the following objectives:

1. Develop builders' education courses utilizing BA details.
2. Continue to promote BA to the homebuilding industry.
3. Promote BAA to the Alaska Housing Authorities.
4. Test and monitor BAA houses built in 2001 & 2002.
5. Compare actual energy use in BAA homes with computer models.
6. Perform economic analysis of the cost to build the BAA house design.
7. Build a Mobile Test Lab to test various wall configurations in SE Alaska.
8. Conduct testing on wall panels for moisture, durability, and energy efficiency.
9. Consult with the Tlingit-Haida Regional Housing Authority on design Review of their house plans to incorporate BAA technologies to reduce energy costs and promote affordability, durability, and a healthy indoor environment.

In the following section of this report we will take a look at each objectives and explain how they were realized.

Objective 1: Develop a builder's education course – Contracted with AEA
Activity: In March, 2002, CCHRC, AHFC, and DOE entered into an agreement with Robert Maxwell, of Alaska Energy Associates (AEA) to develop a 4-hour course on BAA approaches to residential construction and possible retrofits. The target audience was to be home-builders and owner-builders.
Activity: AEA introduced elements of this course into the current 16-hour Cold Climate Homebuilder's Class given to general contractors for their residential endorsement.
Activity: AEA created power point slides with technical information for inclusion in classes.[7]

The 4-hour Building America in Alaska power point production was presented publicly for the first time on Dec. 2, 2004 as part of a group of classes for contractors' license re-certification and residential endorsement Continuing Education Units. The course outline follows.

Building America In Alaska Course Outline

Objectives: To provide detailed information on Building America in Alaska activities and information to the residential builder and other interested individuals.

	Minutes
Attendance,- sign in sheet	5
Introductions – instructor qualifications	5
Overview – Building America Program (overview)	5

[7] Appendix D 4--Hour Building America in Alaska CD

Building America in Alaska - history	5
Optimum Value Engineering	30
Advanced Framing	30
Building America in Alaska I - Activities	30
break	
Building America in Alaska II – Activities	40
REMOTE building system	60
Study Results	20
Wrap-up, Q& A	

Objective 2: **Promote BA in the Building Industry and Public – CCHRC**
Activity: Create a booth to promote BA technologies for Alaska.
Activity: Participate in annual Fairbanks, Anchorage, and Southeast Home Shows and distribute educational materials to showcase the BA project.
Activity: Expand the BA coverage in the CCHRC web page.
Activity: Publish information in the CCHRC newsletter.

On February 19, 2004 Mike Musick, program manager for Building America in Alaska, flew to Juneau, Alaska to represent BAA and CCHRC at the Juneau Home Show over the weekend of February 20, 21, and 22, 2004. He passed out several hundred of 3 different DOE brochures on Building America including tri-folds on *Building for the 21st Century* and *Research That works!* and the 81/2 x 11 inch *Building America Program Overview*. A couple of hundred 6" rulers from DOE proclaiming that *Research Works* disappeared like sourdough hot cakes at a builders' breakfast.

Juneau residents were especially interested in the research conducted by students in the Construction Technology class at the University of Alaska Southeast. The UAS students had designed, constructed, installed, and were monitoring 9 different wall systems. Several photos of the Mobile Test Lab and detailed drawings of the various walls being tested were posted on a table top display along with photos of homes constructed in Alaska using BA techniques. We had a booklet of the charts and graphs showing the relative humidity, temperature, and dew point of each wall panel as well as weather data collected by the met station attached to the MTL.[8] This booklet provided a focal point for discussing the research ongoing at UAS and the concurrent application of this information by the Tlingit-Haida Regional Housing Authority in several homes in Juneau. Mike gave a power point presentation on BAA featuring the REMOTE wall system to an enthusiastic audience of home buyers and home builders at the Juneau Home Show. In the course of the weekend Mike spoke to several hundred people about CCHRC and Building America in Alaska.

On Friday, February 27, Mike flew to Ketchikan to set up for the local building association Home Show held on the 28th and 29th. The set up in Ketchikan was essentially the same as in Juneau. The booklet on the Mobile Test Lab provided a point of interest for residents of Ketchikan to learn about the results of the BAA research at

[8] Appendix B Monitoring of Wall Drying Characteristics in a Temperate Rain Forest Environment

UAS. Mike spoke to several hundred people about CCHRC and Building America in Alaska.

Over the weekend of March 26, 27, & 28 CCHRC staff covered the Home Shows in Fairbanks and in Anchorage. In Fairbanks Mike Musick set up the CCHRC display booth at the main entry where he personally welcomed most of the more than 8,000 attendees at the Home Show. Several hundred people stopped by the booth to discuss the ongoing research performed by contractors to CCHRC. As in Southeast Alaska, people in the Interior were intrigued by the BAA research results demonstrating the efficacy of the REMOTE wall system. Preliminary research results in the Fairbanks area indicate that this wall system is appropriate even in the dry, windless, Interior Alaska. In order to promote Building America in Alaska at the Anchorage Home Show (which fell on the same dates as the Home Show in Fairbanks) John Davies, Research Director at CCHRC flew to Anchorage to set up a booth on March 26, 2004. Over the weekend the Anchorage Home Show attracted 10,565 attendees many of whom stopped by the CCHRC booth to look at the displays and pick up DOE Building America brochures. John was interviewed by a local TV broadcaster who created a 1-2 minute production about the CCHRC/BAA booth that was broadcast on Saturday and Sunday during the Home Show and for the next five days to the largest television audience in Alaska. The CCHRC has pre-registered with the Anchorage Home Building Association to reserve a booth for the Home Show in the spring of 2005. In addition to the public outreach efforts noted above, CCHRC has promoted BAA on its web site and newsletters.[9] Selected press releases and newsletters can be found in Appendix A.

Objective 3: Promote BAAII to the Alaska Housing Authorities-CCHRC
Activity: Send an information packet outlining the BAAII program, including design details and building techniques to 15 AAHA offices. These have been sent.[10]

Activity: Conduct BAAII presentations at AAHA annual meeting.

Information packets have been sent to the Regional Housing Authorities including brochures from the US Department of Energy and a brief description of Building America in Alaska.

Jack Hebert, President/CEO of CCHRC and John Davies, Director of Research at CCHRC, have delivered BAAII presentations to the Association of Alaska Housing Authorities and to housing authority staff at three events sponsored by the Office of Native Americans Program (ONAP).

<u>Presentations to Native Housing Authority Personnel</u>
Jack Hebert and John Davies made three presentations to personnel of Alaska Native housing authorities who were attending mold-training seminars sponsored by the Alaska Office of Native American Programs (ONAP). The attendance at these seminars

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[9] *www.cchrc.org*
[10] Appendix E BAAII Packet for Housing Authorities

averaged about 30. Don Clem of *Steven Winter Associates* presented the trainings under a contract with HUD. We made a Power Point presentation that introduced the Cold Climate Housing Research Center and described several of our research projects. The Building America in Alaska was one of the projects that we featured in these presentations. Two of the seminars were held in Anchorage in April of 2003 and 2004, and the third was in Fairbanks during November 2004.

Objective 4: Evaluate BA building performance in Alaska- Contracted with AEA
Activity: Follow-up monitoring including infrared thermography, VOC, CO, particulates & humidity on 8 homes (4 in Fairbanks, 2 in Juneau, 2 in South Central Alaska).
Activity: Compare results with those from other CCHRC studies.

The following is a report by Robert Maxwell of Alaska Energy Associates **(AEA)**

Building America in Alaska Two (BAAII)
Building America in Alaska Home Performance Evaluation

Indoor Air Quality

Three BAAII homes were tested for Carbon Monoxide, Volatile Organic Compounds (VOC's) and Formaldehyde. The results showed that BAA homes were well within the average range of what we have found in other homes within Alaska.

Introduction

The *Building America in Alaska II* REMOTE dwelling (BAAR) was tested in Fairbanks during the summer of 2004 when the outdoor air quality was contaminated by smoke caused by wildfires and may not be comparable to any of the other air samples. The BAAII REMOTE construction approach is a wall system designed for durability in wet climates and drying potential in extreme cold condensing climates.

The other two BAAII houses tested for VOC's and formaldehyde were a structural insulated panel system (SIPS) home located in Palmer Alaska referred to as BAAP, and a Ninilchick, Alaska house built based on the design developed during BAAI referred to as BAAN. Both of these houses used the BAAI design.

CCHRC has also completed a study of VOC's found in several homes across Alaska, three located in Fairbanks and two in the Juneau area. This gives us a basis for comparison between the BAAII houses and a range of normal construction across Alaska.

Methodology

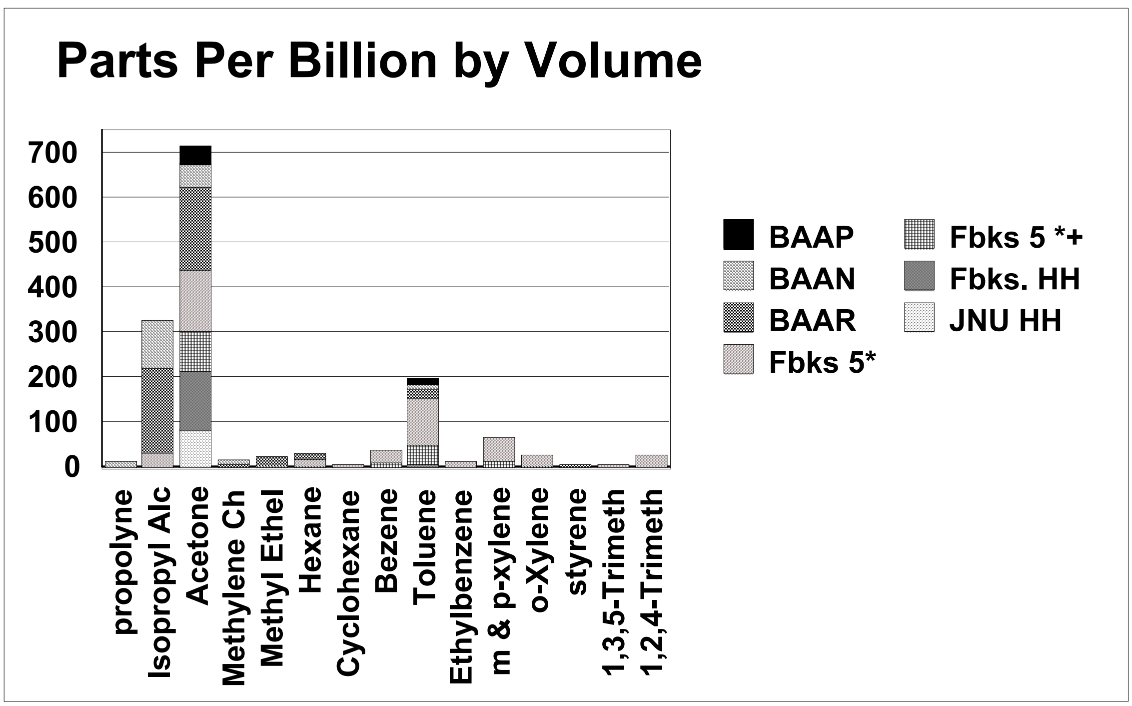
All of the homes were tested during winter or inclement weather months when the homes were without natural ventilation from open doors or windows. The testing method used whole air sampling in minicans from Galson Laboratories. Samples were sent to Galson for analysis using EPA TO15 analytical method. In addition to testing for the 63 known VOC's, the samples were compared to a list of 75,000 Tentatively Identified Compounds (TICs).

In addition to the air samples, the homes were tested for formaldehyde, using the SKC Indoors Air Sampler 526-100, a badge collection medium. The analytical method utilized was Modified OSHA ID205-color. The level of quantification was 0.40 micrograms (ug), and the minimum measurable concentration level was 0.01 parts per million (ppm). The level of formaldehyde concentration acceptable for people based on 8 hours per day/40 hour week for the duration of his/her working career according to OSHA is .75ppm.

Results

The following chart shows the levels of VOC's found in BAAII and comparison houses. If the amount of the VOC was below the measurable limits (usually between 5 and 20 parts per billion by volume) then it would not appear as being present in the air samples.

VOC's in BAA II and Other Alaska Homes



VOC’s in BAAII and other Alaska Homes

	Parts Per Billion by Volume						
	JNU HH	Fbks. H	Fbks 5 *+	Fbks 5*	BAAR	BAAN	BAAP
propolyne						11	
Isopropyl Alcohol				35	187	106	
Acetone	85	132	87	138	185	51	39
Methylene Chloride					10	7	
Methyl Ethel Keytone			6		16		
Hexane			6	15	10		
Cyclohexane				7			
Bezene			11	28			
Toluene		8	43	106	21	10	10
Ethylbenzene				12			
m & p-xylene			16	50			
o-Xylene			5	21			
styrene					6		
1,3,5-Trimethylbenzene				6			
1,2,4-Trimethylbenzene				25			

Tentatively Identified Compounds

A Tentatively Identified Compound, TIC, is a compound that the testing instrumentation can detect but the analysis is not targeting specifically. Its identity and concentration cannot be confirmed, as the laboratory does not have the calibration gases for every compound available within the Gas Chromatography Mass Spectrometry library.

From a library of over 70,000 compounds, the following were found in BAAII Homes. The concentrations and the quantities found in the lists are comparable to those found in other VOC studies conducted by CCHRC. Many of these compounds such as Limonene are found in household cleaners.

Client ID : BAAR   Lab ID : L109272-1

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration	Units
Unknown Fluorinated Hydrocarbon		5.59	5.7	ppbv
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	5.91	100	ppbv
Isobutane + Acetaldehyde (CAS 75-07-0)	000075-28-5	6.10	29	ppbv
Ethanol	000064-17-5	7.12	95	ppbv
Pentane	000109-66-0	8.37	5.7	ppbv
Methyl acetate *	000079-20-9	8.84	5.7	ppbv
Pentanal	000110-62-3	14.83	8.8	ppbv
Hexanal	000066-25-1	17.86	25	ppbv
Cyclotrisiloxane, hexamethyl-	000541-05-9	18.71	17	ppbv
.alpha.-Pinene	000080-56-8	21.00	14	ppbv
Cyclotetrasiloxane, octamethyl-	000556-67-2	21.54	23	ppbv
Limonene	000138-86-3	22.17	26	ppbv

Client ID : NINILCHICK   Lab ID : L109272-2

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration	Units
Acetaldehyde	000075-07-0	6.10	10	ppbv
Ethanol	000064-17-5	7.12	240	ppbv
1,3-Pentadiene	000504-60-9	8.51	7.9	ppbv
Hexanal	000066-25-1	17.86	7.8	ppbv
Cyclotrisiloxane, hexamethyl-	000541-05-9	18.72	9.3	ppbv
Cyclotetrasiloxane, octamethyl-	000556-67-2	21.54	17	ppbv
Limonene	000138-86-3	22.17	7.8	ppbv
Undecane	001120-21-4	22.83	5.7	ppbv
Dodecane	000112-40-3	23.83	8.2	ppbv

Client ID : PALMER   Lab ID : L109848-1

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration	Units
Acetaldehyde	000075-07-0	6.15	8.1	ppbv
Ethanol	000064-17-5	7.16	57	ppbv
1,1-Dichloro-1-fluoroethane	001717-00-6	8.14	22	ppbv
Hexanal	000066-25-1	17.90	15	ppbv
Cyclotrisiloxane, hexamethyl-	000541-05-9	18.75	12	ppbv
Cyclotetrasiloxane, octamethyl-	000556-67-2	21.57	14	ppbv

The formaldehyde readings inside the eight dwellings sampled are shown below. The Juneau Health House after occupancy sample showed no measurably detectable formaldehyde.
None of the formaldehyde samples exceeded the OSHA standards of .75ppm, yet they do exceed the ATSDR MRLs of .04ppm for acute inhalation exposure.
With the exception of the Juneau Health House, all other homes showed an increase in formaldehyde after occupancy. It would be reasonable to conclude that the increase is related to occupant choices of materials introduced into the dwelling, such as furniture.

Formaldehyde concentrations were found for BAAR, BAAP and BAAN as follows:

BAAR	0.04 ppm
BAAN	0.009 ppm
BAAP	0.01 ppm

These compare favorably to (and generally less than) the levels found in the after occupancy below from other studies performed by CCHRC.

FORMALDEHYDE	JNU 5 *	JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*
Formaldehyde (ppm)	0.089	<0.01	0.064	0.04	0.075

Particulates were measured as well as CO levels in all of these homes, and in review we see that they did no better nor worse than the standard houses measured in other CCHRC studies. An AREOCET counter was used to measure and correct the particulate data.

Particulate counts in the BAAR home were obviously impacted the wildfire smoke and not comparable to any other count taken in any BAAII studies.

BAAR Indoor Particulate

MASS		COUNTER	
PM 1	0.033	0.5 micron	6,568,256
PM 2.5	0.128	5.0 Micron	95,750
PM 7	0.147		
PM 10	0.151		
TSP	0.155		

BAAN Indoor Particulate

MASS		COUNTER	
PM1	0.007	0.5 micron	3,538,210
PM2.5	0.029	5.0 micron	17,470
PM7	0.083		
PM10	0.132		
TSP	0.196		

BAAP Indoor Particulate

MASS		COUNTER	
PM1	0.006	0.5 micron	121,846
PM2.5	0.008	5.0 micron	5,700
PM7	0.034		
PM10	0.050		
TSP	0.102		

Carbon Monoxide

None of the BAAII homes exceeded .2ppm CO readings, including the BAAR dwelling. An ONSET HOBO datalogger was used to collect the data.

Minimal Risk Levels (MRLs) for Hazardous Substances

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 U.S.C. 9604 et seq.], as amended by the Superfund Amendments and Reauthorization Act (SARA) [Pub. L. 99-499], requires that the Agency for Toxic Substances and Disease Registry (ATSDR) develop jointly with the U.S. Environmental Protection Agency (EPA), in order of priority, a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List (NPL) (42 U.S.C. 9604(i)(2)); prepare toxicological profiles for each substance included on the priority list of hazardous substances, and to ascertain significant human exposure levels (SHELs) for hazardous substances in the environment, and the associated acute, subacute, and chronic health effects (42 U.S.C. 9604(i)(3)); and assure the initiation of a research program to fill identified data needs associated with the substances (42 U.S.C. 9604(i)(5)).

The ATSDR Minimal Risk Levels (MRLs) were developed as an initial response to the mandate. Following discussions with scientists within the Department of Health and Human Services (HHS) and the EPA, ATSDR chose to adopt a practice similar to that of the EPA's Reference Dose (RfD) and Reference Concentration (RfC) for deriving substance-specific health guidance levels for non-neoplastic endpoints. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. These substance-specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites. **It is important to note that MRLs are not intended to define clean-up or action levels for ATSDR or other Agencies**

The EPA Resource Conservation and Recovery Act (RCRA) guidance levels were exceeded for the following VOCs in this study for the Fairbanks Five Star Home. None of the BAAII homes found measurable levels of these substances.
It should be noted that three of the four RCRA screening level concentrations above are well below the detectable concentration in the laboratory analysis. This indicates that there could have been other VOCs present in the samples that exceeded the RCRA guidelines, yet did not show up in the air sample reports.

VOC Concentrations in the Fairbanks Five Star Home: (parts per billion by volume)

Compound	Concentration Detected (ppbv)	RCRA screening level (ppbv)
Benzene	28	0.098
Ethylbenzene	12	5.1
1,3,5-trimethylbenzene	6	1.2
1,2,4-trimethylbenzene	25	1.2

Discussion

VOC measurement should be continued in all homes studied under CCHRC oversight. A larger sample will eventually result in a clearer picture of what we should expect in the way of background VOC's found in indoor air in cold climates. In regard to the BAAII project, what we are able to determine is that the Building America in Alaska homes are comparable to the other samples taken in other studies.
Many MRL's are well below the measureable level using the minican methodology and we should look at sampling that can measure below the five and twenty ppbv that many VOC's have as the minimum threshold for detection.

Infrared Scans

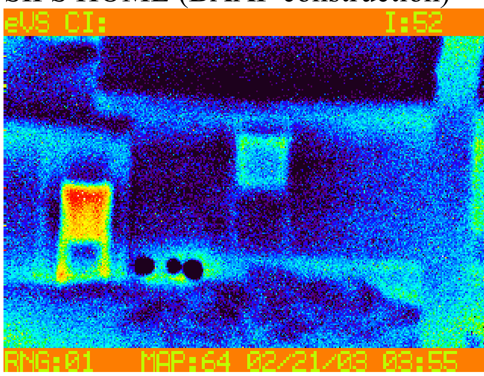
Due to time and availability of good IR scanning temperatures and equipment issues, the IR comparisons were limited.

Methodology

The CCHRC Raytheon infrared camera was used to scan buildings from the exterior when the interior of the building was at least 30 degrees warmer than the exterior temperature. Scans showed areas where the heat loss was most pronounced in comparison to adjoining surfaces.

Results

SIPS HOME (BAAP construction)

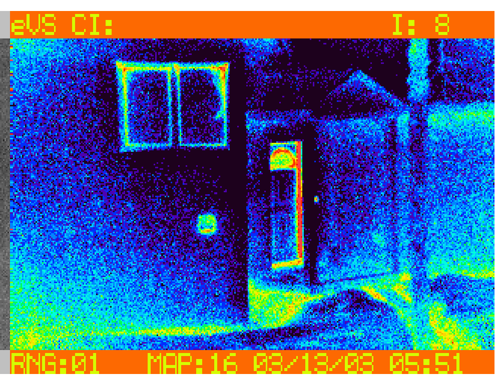


-14 degrees F exterior Temp

36 degrees F exterior Temp

The subzero temp shows minor conductive heat loss between panel joints under window. While trees obstruct the same area in the photo on the right, the same areas of heat loss were not seen in the camera. Door and garage door continued to show conductive heat loss greater than building shell in both photos.

REMOTE HOME (BAAR Home)



No significant heat transfer in either temperature range through the wall system Ground surrounding the home shows as warmer however this is a normal condition that would be expected in the interior of Alaska.

Objective 5: How accurate is AKWarm in predicting energy use? –Contracted with AEA
Activity: Compare AKWarm modeling to actual performance on same 8 homes in objective 4.

The following is a report by Robert Maxwell of Arctic Energy Associates.

Comparison of AKWarm Estimated Energy Use to Actual Energy Consumption

I. Introduction

Each of the homes in the study received an AKWarm energy rating that also estimated annual energy use. The estimate was broken down into energy used for space heating, water heating, and appliances and lighting, and fuel sources were based on rater input.

Many of the house samples did not have adequate energy use data to perform a comprehensive analysis of the dwelling compared to AKWarm. Notes to the table indicate which homes had a partial year of fuel use data to compare to AKWarm. The results below are a best estimate given limited data.

AKWarm Energy Estimates

- AKWarm bases annual space heating estimates on monthly and yearly average heating degree days (HDD) at the National Weather Service location in each community. The National Weather Service provides 30-year monthly data for 21 primary locations around the state. All other communities are tied to the primary location nearest them for solar data, monthly HDD, and wind. If there is available annual heating degree data for that community, it is included. There are also many micro-climates within a community that cannot be considered in a program such as AKWarm.
- Besides HDD, AKWarm uses monthly solar gain when calculating a building's heating needs. Solar gain figures are only available for 6 primary locations in Alaska and all other communities use nearest available data. This study was not able to evaluate a difference between actual solar gain for specific year and AKWarm predicted solar gain.
- AKWarm estimates the seasonal efficiency of the heating system, based on the AFUE listed by the rater. No actual test of the heating system is made.
- AKWarm bases annual water heating energy costs on standardized water heating consumption for the number of occupants.
- AKWarm bases appliance and lighting estimates on generic averages for homes of particular sizes in particular locations of the state.

2. Methodology

This study looked only at energy use comparisons, not energy costs. Energy costs fluctuated dramatically during the study time. AKWarm's estimated costs are updated bi-annually.

For each home, AKWarm ratings as well as actual fuel and electric consumption data were obtained when available.

Whenever possible, actual temperature data (HDD) was obtained for each location and compared to the data used in AKWarm.

3. RESULTS
Because so much of AKWarm's estimated energy use is based on the weather data at a particular location in the state, this portion of the study is organized by location.

A. Juneau
AKWarm in Juneau
Juneau is the only location in the state for which AKWarm has provided 2 weather locations. The official weather station is at the airport, but the City of Juneau has significantly different weather. Both homes in this study used the Juneau Airport records. The data obtained from AEL&P for 2003 HDD also used the official Juneau weather station at the airport.

Building America/Juneau
Two Building America homes in Juneau were included in the study. One was an all electric home, using a ground source heat pump (Juneau HH) and the other was space heated with oil. (Southeast REMOTE)

House #1: **Juneau HH** - 5-Star Plus (96.2) All-electric – ground source heat pump for space/water heating
Since this was an all-electric home, there were very good and detailed records available from Alaska Electric Light & Power. As well as kWh usage, the monthly records included HDD and kWh/HDD. Records were available from May 2001 through July 2004, and they showed a very consistent pattern of usage that made it reasonable to assume 1000 kWh/month was for appliances/lighting and to assign the rest to space heating and water.

AKWarm Estimates	KWH
Space heating:	10,368 kWh
Water heating:	2,405 kWh
Appliances:	9,346 kWh
Total	22,119 kWh

AEL&P Electric Records

Month	2001	Kwh / dd	2002	kwh /dd	2003	kwh /dd	2004	kwh /dd
Jan			3200	3	3366	3	3704	3
Feb			2272	2	2791	3	2672	3
Mar			2308	2	3072	3	3010	3
Apr			1987	2	2079	3	2151	3
May	33		1437	3	1833	3	1344	4

Jun	42		1332	5	1556	5	1424	5
Jul	57	1	1423	4	1435	7	1106	7
Aug	146		1422	5	1406	5		
Sep	106	3	1547	3	1759	3		
Oct	2406	7	2076	3	2099	3		
Nov	6471	4	2334	3	2802	3		
Dec	4080		3397	3	3356	3		
Total			24735		27554	3		
Average			2061	3	2296	3	2202	
kwh/rd				68		76		

House #2 Juneau

Glacier View Subdivision – Southeast REMOTE
Oil consumption: Unfortunately, fuel records were not complete enough to provide a meaningful comparison. The resident orders fuel on an as-needed basis and usually orders 100 gallons. That makes it difficult to know how much was actually consumed. We made an assumption based on the data below that the 300 gallon tank was filled on 01-23-04 and 08-27-04 and therefore we estimate that 450.1 gallons were used in between those two dates.

<u>AKWarm Estimates</u>

Space heating:	513 Gallons #2 oil
Water heating:	218 Gallons #2 oil
Total	731 Gallons #2 oil

Actual

01-23-04	258.10 gals.	04-28-04	100.00 gals.
03-31-04	100.00 gals.	08-27-04	250.10 gals.

House #2 Juneau continued

Given the assumptions:
Oil tank was full on Jan 23, 2004 and on August 27, 2004
Total oil consumption for these 7 months was 450.1 gallons
<u>Plus</u> the following assumptions:
Actual water heating consumption was the same as AKWarm estimates (I have no way of knowing how much of the total oil consumption was for space heating vs. water heating)
Water heating consumption is consistent throughout the year, so that the AKWarm estimate of 218 gallons per year for water heating can be assumed to be 129.6 gallons for the 217 days between Jan. 23 and August 27, 2004 (including Leap Day)
Then, space heating consumption for the same period was 450.1 gallons – 129.6 gallons = 320.5 gallons
Then, using AEL&P records for this house during this period, there were 3865 HDD.

Using monthly AKWarm data for average HDD during this period, HDD = 4579 which was 0.5 of the total 9105 HDD for Juneau in an average year.
AKWarm predicted 513 gallons of fuel for annual space heating. Dividing that number by 0.5 = 256.5 gallons
AKWarm's HDD adjustment for the study period is 3865/4579 = .84

Therefore, the AKWarm unadjusted prediction of 256.5 gallons was 80% of the estimated actual space heating consumption (320.5), and HDD-adjusted prediction of 215.5 is 67% of the estimated actual space heating consumption (320.5).

B. Ninilchik

AKWarm/Ninilchik
AKWarm uses Homer weather data for Ninilchik, but with an adjusted annual average HDD. The only weather station currently recording nearby is Homer. Homer had 9408 HDDs in 2003. (Western Regional Climate Center, Reno, NV). Homer has 10349 HDD in AKWarm, slightly higher.

AKWarm Estimates	
Space heating:	381
Water heating:	218
Total	599 Gallons #2 oil

BuildingAmerica/Ninilchik BAAN
The Building America house in Ninilchik has a 300 gallon fuel oil storage tank, and according to Ninilchik Traditional Council records, it was filled twice during the year. There is no more complete data available. If we could assume that it was filled completely each time, this would make fuel oil usage be about 600 gallons per year. There were 2 people living in the house at the time of the rating and 6 people live there now. This would greatly affect the actual water heating and slightly affect other energy usage.

C. Palmer

AKWarm/Palmer
Palmer uses Wasilla weather data with a HDD modification for Palmer. Palmer's weather station closed in 1998, so there is no official HDD for the current year.

Building America/Palmer BAAP
This home was not occupied until the end of February 2004. The home used natural gas for space and water heating, clothes drying and cooking. In AKWarm, cooking, clothes drying and water heating usage are default values. Water heating is based on the occupancy. The AKWarm rating file listed occupancy as 3, but in fact there was only 1 occupant during the entire study time. This change affected AKWarm predictions by increasing space heating from 500 ccf to 526 ccf, and lowering water heating consumption from 197 ccf to 80 ccf. Overall change went from annual prediction of 800 ccf of natural gas to 709 ccf.

AKWarm Estimates
Space heating: 526 CCF Natural Gas
Water heating: 80 CCF Natural Gas
Appliances 106 CCF Natural Gas
Total 712 CCF Natural Gas

Natural gas records go from Feb 25, 2004 – October 25, 2004. Monthly HDD information is from March 1, 2004- October 25, 2004.

Actual gas consumption for March- Oct, 2004

Actual gas – 8 months	Actual HDD	Actual ccf/HDD	AKWarm 8 month prediction using actual HDD	Comparison: AKWarm/actual
290 ccf	3516	0.08	.065*3516= 229 ccf	229/290 = .79
Using 3 occupants as shown in rating:			.074*3516= 259 ccf	259/290 = .92

However, comparing monthly HDD and ccf consumption, we get variable results for ccf/HDD, indicating that there are more variables going on here than can be explained by HDD, because there is no consistency in summer months. This strengthens the case for at least a full year of fuel data in order to accurately compare predictions with use.

Palmer	Mean T	HDD	Ccf	ccf/HDD
March	29.23	1108.87	97	0.09
April	43.7	639.00	77	0.12
May	55.79	285.51	31	0.11
June	61.64	100.80	16	0.16
July	64.35	20.15	11	0.55
Aug	63.39	49.91	11	0.22
Sept	47.8	516.00	12	0.02
October	39.32	796.08	35	0.04
	TOTAL	3516.32	290	

D. Fairbanks
AKWarm/Fairbanks
Fairbanks is one of the primary weather stations for Alaska, so solar and wind data is available here and no adjustments have been made to the location for HDD. Any differences would be in local micro-climate.

Building America/Fairbanks BAAR
This home was 5 Star Plus home (94.2 pts) with oil space heating with an efficient side-arm boiler.

AKWarm Estimates
Space heating: 667 Gallons #2 oil
Water heating: 140 Gallons #2 oil

Total 807 Gallons #2 oil

Fuel Usage for 2003

Date Delivered	Gallons
Jan 3, 2003	466.3
May 27, 2003	517.1
Oct 21, 2003	208.1
Jan 5, 2004	356.0
Total	1081.2

Summary

HDD Adjustments

Location	AKWarm HDD	Actual HDD for Study Year	Difference
Juneau	9105	8897 (2003)	.98
Juneau	4579 (Jan 23 – Aug 27 2004)	3865	.84
Ninilchik	11,155 (Ninilchik) 10,349 (Homer)	9403 (Homer 2003)	.91(Homer)
Palmer	10,869 (Palmer)	No information	No change

Space/Water Heating Comparisons

House	Location	Actual Space/Water Heating Fuel	AKWarm predicted	AKWarm Predicted Fuel (adjusted for actual HDD)
1	Juneau All electric[1]	12000 kWh	12773 kWh	12517
2	Juneau – oil[2]	450.1 (rough estimate)	393 gal	330 gal
3	Ninilchik – oil[3]	600 (rough estimate)	599 gal	539 gal
4	Palmer – gas[4]	709 (partial year)	697 ccf	697 ccf
5	Fairbanks – oil[5]	1081 gal	689 gal	675 gal

NOTES:
1 Since this house was all-electric, it was not possible to distinguish between space/water heating and appliance/lighting usage. This assumes 1000 kWh/yr for appliances and lighting. AKWarm estimates 9346 kWh for appliances.
2 The fuel records were incomplete, but rough estimates were made for period from Jan. 23- Aug. 27, 2004.
3 The fuel records were not detailed. 300 gallon tank was filled twice during year.
4. Occupant was only in this home for 7 months, not including the winter season. This home had a natural gas clothes dryer and cooking range, so the total actual ccfs used included this usage. AKWarm predicted 103 ccf for these appliances.
5. We have no explanation for the extreme discrepancy between predicted and actual, despite significant attempts to find one.

Discussion:
It would be valuable to collect reliable records for these homes for a longer period of time, at least through the current winter. Some occupants had not been in their home long enough to make a useful analysis. It is never easy to make comparisons between actual and estimated energy use without separate metering and detailed record keeping. So many other variables affect actual energy usage. The very detailed records provided for the Juneau all-electric home indicated that AKWarm estimates can be reliable.

Estimates of actual fuel oil consumption are even more problematic. Records only indicate how much fuel was delivered and may only mean that that was what was ordered, not what would fill a tank. Future studies should make a concerted effort to provide for systematic fuel-data collection from the beginning of the project.

The home in Fairbanks where discrepancy between actual and predicted was so great would be a good candidate for further studies, including co-heat testing. This may help builders determine if they are paying a penalty for over sized heating systems after investing so much into very energy efficient building enclosures.

Objective 6: Economic analysis of Alaska BA houses-CCHRC
Activity: Collect construction costs of the BA houses built in Alaska to analyze savings and compare costs to current construction practices.

The following tables are cost comparisons of REMOTE vs conventional construction in Juneau and Fairbanks:

Cost Comparison - Juneau

Cost Comparison of Conventional Construction vs. REMOTE For the wall of a 32' x 56' single story house (M. George)			
Conventional Construction		**REMOTE Construction**	
Component	Cost	Component	Cost
2x6 stud* (175 @ $4.59)	803	2x4 stud* (175 @ $3.19)	558
R-21 batt insulation	893	3" EPS foam sheathing	662
6 mil polyethylene	64	Bituthane	1152
Tyvek	184	none	0
none	0	PT furring	162
TOTAL – conventional	1994	TOTAL – REMOTE	2534
* vertical lumber est. at 1 stud/ft		Incremental Cost	590

Cost Comparison - Fairbanks

Cost Comparison of Conventional Construction vs. REMOTE For the wall of a 32' x 56' single story house (Jack Hebert)			
Conventional Construction		**REMOTE Construction**	
Component	Cost	Component	Cost
2x6 stud* (175 @ $4.59)	796	2x4 stud* (175 @ $3.19)	513
R-21 batt insulation	964	4.5" EPS foam sheathing	993
6 mil polyethylene	58	Bituthane	861
2x6 plates	295	2x4 plates	197
Tyvek	186	Furring	132
TOTAL – conventional	2299	TOTAL – REMOTE	2696
* vertical lumber est. at 1 stud/ft		Incremental Cost	397

Cost Comparison – Other Issues

Cost Comparison of Conventional Construction vs. REMOTE			
Conventional Extras		REMOTE Extras	
Component	Cost	Component	Cost
Rim joist sealing	+	Insulation installation	+
Window sealing	+	Furring for siding	+
Vapor barrier sealing	+	Window/door flashing	+
Temporary heat	+	Ventilation	+
Callbacks/durability	+		

We also have a report on the cost to construct site-built shear panels developed for Building America by Building Science Corporation. This report can be found under Objective 9.

Objective 7: Develop a BA strategy for Southeast Alaska –CCHRC
Activity: Build a mobile wall testing facility to accept wall panels of different construction to test under various conditions.

In December 2002 CCHRC contracted with Bulletproof Trailers to construct a 24' x 8'4" Mobile Test Lab at their fabrication shop in North Pole Alaska. Bulletproof Trailers constructed a super insulated custom chassis/floor system upon which to attach a custom built, pre-fabricated, urethane filled, fiberglass reinforced plywood panels wall and roof package. The Mobile Test Lab (MTL) was delivered to the University of Alaska Southeast Construction Technology Center in Juneau in early March 2003. See Objective 8 below and Appendix B for more details, drawings, and photos of the MTL.

Objective 8: Conduct testing of wall panels – University of Alaska Southeast (UAS)
Activity: Build different wall assemblies to test:

- Advanced frame wall with Tyvek & vinyl siding
- Advanced frame wall with Tyvek & cement board siding
- Advanced frame wall with Tyvek, rain screening and wood siding
- Advanced frame wall with Tyvek & T-111 siding
- Advanced frame 2x4 walls with outsulation and all above sidings
- PERSIST (REMOTE) wall with vinyl siding
- ICF wall with stucco siding

Activity: Monitor wall assemblies in testing facility.
Activity: Report on performance of test wall assemblies. (Not all wall configurations listed above were tested. See Appendix B for details).

UAS Construction Technology students installed a vanEE heat recovery ventilator in the workshop area of the MTL to control airflow and with the aid of a humidifier, the relative humidity in the test lab. A weather station was installed high on an outside wall of the MTL The weather station transmits data to a remote terminal that records outdoor and indoor temperature, barometric pressure, relative humidity, dew point, rain fall, and wind speed and direction. A small photovoltaic panel powers the weather station.

Students at the Tech Center constructed nine different 4x8 wall panels to the design specifications provided by the CCHRC Southeast Research Advisory Committee (RAC). The RAC designed typical wall systems commonly used in Juneau as well as advanced BA framed walls. One of the designs the students constructed was a new framing system developed by CCHRC in Fairbanks called the REMOTE wall.

The **R**esidential **E**xterior **M**embrane **O**utsideinsulation **TE**chnique is an Alaskan adaptation of the PERSIST wall system developed by Canadian researchers several years ago. The REMOTE construction sequence begins like any 2x4 advanced wall framing system wherein the frame is built and sheathed laying on the subfloor. At this stage a peel and stick ice and water shield membrane is adhered to the outside of the structural sheathing before standing the wall. Two layers of rigid foam are mechanically attached through the membrane and sheathing into the studs paying careful attention to offsetting joints in the foam. Any suitable siding can be attached to nailer strips or the foam can be finished with a synthetic stucco system. The REMOTE wall system is especially suited to building in the Southeast Alaska rain forest where moldy, soggy, and rotting building materials do not have a chance to dry out. In the REMOTE wall system all of the thermal envelope, including the vapor barrier, are exterior to the structure. All the joists, studs, plates, and structural sheathing are kept warm and dry and never reach the dew point temperature and therefore never experience condensation problems.

The nine wall configurations were each fitted with one HOBO® LCD Temperature & Relative Humidity data logger (Model # H14-001) installed in the center stud bay, secured to the inside of the structural sheathing 18 inches below the top plate. Moisture measurements were taken using a GE Protimeter Survey Master moisture meter.

UAS Construction Technology students monitored the performance of the 9 different wall systems in the Mobile Test from May 2003 to May 2004. Only the REMOTE wall system showed a drying trend over the course of the year.[11]

The CCHRC Southeast Alaska Research Advisory Committee (RAC) reviewed the preliminary research report prepared by Assistant Professor of Construction Technology, Marquam George, who also happens to be chair of the Southeast Alaska RAC.
The recommendation of the RAC was to construct a variety of REMOTE wall systems to test for another year if funding can be obtained for this research.

Objective 9: Design review of Tlingit-Haida house plans – UAS
Activity: Design work with Tlingit-Haida Regional Housing Authority 2002 development project to incorporate BAA technologies into their new and existing buildings.
Activity: Documentation and closure report.

In addition to collaborating on the design of T-HRHA residential structures, Professor George assisted the Housing Authority with three research studies:

1. On-Site Constructed Wood Shear Panels
2. REMOTE Wall Assembly
3. Inline Ventilation

The site-built shear panels were modeled after the Building Science Corporation “P3-3 Plywood Shear Panel” that had been tested and approved by the Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Lab.[12] The object of using engineered shear panels was to save on structural sheathing materials, reduce potential for condensation on the structural sheathing and increase the overall R-value of the wall assembly. The builder was less than satisfied with this approach

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[11] Appendix B Monitoring of Wall Drying Characteristics in a Temperate Rain Forest Environment, Marquam George, 2004
[12] ERDC/CERL TR-00-DRAFT; Nov. 2000

because of the difficulty in locating exterior fasteners and placement of ladders on a two-story structure.

The Tlingit-Haida Regional Housing Authority constructed their first REMOTE home in Phase 1 of their Glacier Village subdivision with technical assistance from Marquam George under the Building America Alaska program. The design for this home included the crawl space as part of the conditioned space resulting in a higher energy rating and improved indoor air quality. The REMOTE wall system was monitored for temperature and relative humidity and compared to the performance of a conventional wall. The data logging verified the superior performance of the REMOTE wall. The success of this home has encouraged T-RHA to continue adapting REMOTE in future construction projects.

Inline ventilation was installed in this home. A two-fan system provided a continuous supply of filtered and tempered fresh air to each bedroom, and continuous exhaust from each bathroom and the crawl space. The crawl space maintained an average temperature of about 69° F and an average RH of 37%. Bedroom supply air was an average of 57.5° F with an average RH of 59%.[13] The supply air mixes with the room air resulting in a comfortable indoor environment. The continuous exhaust system is designed to control RH levels to avoid condensation issues in the thermal envelope including windows. The crawl space is warm and dry which is a rarity in Southeast Alaska.

Details of the on-site built shear wall panels, REMOTE wall construction, and inline ventilation are included in the following Building America-Alaska Southeast Alaska Project Report.

Building America – Alaska
Southeast Alaska Project Report
Marquam George

<u>On-site Constructed Wood Shear Panels</u>

This study was to incorporate on-site wood shear walls with comparison to plywood or oriented strand board fully sheathed walls. Successful integration would include acceptance of the regional engineering community to satisfy local building code compliance, material and labor cost savings to the builder, and improved building performance and durability to the dwelling owner.

The primary Building America-Alaska building partner in Southeast, Tlingit Haida Regional Housing Authority (THRHA) initially supported the concept of constructing Building Science Corporation's on-site shear walls to further assess their applicability with advanced framing approaches. In the long run THRHA withdrew using this concept with their construction projects for an unknown reason. A Juneau builder was able to incorporate this advanced framing method with one single-family residence.

[13] Personal communication with Marquam George 9/9/04

The shear panel was constructed to closely resemble the Building Science Corporation wall panel (P3-3 Plywood Shear Panel) as tested by the US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL TR-00-DRAFT; November 2000).

Anticipated benefits of this framing system were, (1) to decrease labor and material costs by using a lesser amount of structural sheathing in exchange for a rigid insulation foam sheathing, and (2) more importantly, by trading foam for wood, reducing the likelihood of cold surface condensation occurring on the structural sheathing.

A local engineering firm reviewed the CERL draft study and adjusted the design of the plywood shear panel to be locally approved and incorporated for the project. The site available for this wall panel was an exposed beachfront lot. Because of the regional design considerations, the local engineers modified the panels with additional framing members and a higher grade of plywood than in the draft study.

Material Costs Comparisons:

1½” EPS 4x8 (beadboard)	$ 7.75
½” CDX plywood	$16.15
7/16” OSB	$10.45

Cost trade-offs using expanded polystyrene foam:
52% less than ½” CDX plywood
26% less than 7/16” OSB

Insulation/Thermal bridging:
R-value without exterior foam sheeting R-19.2 (2x6 @ 24” O.C., R-21 batt.)
R-value with exterior foam sheeting R-25.8

Increasing the assembly overall R-value by 26% while eliminating a susceptible cold surface to condensation is a monetary benefit both to the builder and the building owner. However, utilizing this framing system was found troublesome with exterior-side attachment points, both with fasteners, but also for setting an extension ladder against the building. These two shortcomings would suggest this system is more appropriate for a stucco-like cladding and a one-story height. After trying to incorporate this system, the feedback from the builder and the crew was this system was unlikely to be useful.

REMOTE Wall Assembly

Tlingit Haida Regional Housing Authority (THRHA) constructed their first REMOTE assembly in Phase 1 of their Glacier Village subdivision. A one story, two bedroom was selected; architectural modifications were made by THRHA staff with technical assistance provided through Building America Alaska.

Besides the architectural design assistance, technical help was provided with obtaining building permit approval. Above and below grade components were analyzed for energy performance. This assessment identified realigning of the thermal boundary to be incorporated not just for the REMOTE dwelling but also for all of the subdivision houses. This boundary shift allowed THRHA to score an improved AkWarm© energy rating. This change was to include the crawl space as part of the living and conditioned space instead of outside and not included in the thermal volume.

Prior to starting construction a two-hour training was provided to THRHA supervisors, construction crew personnel and the subcontractors to familiarize each with the details to be overcome with REMOTE and the potential benefits.

During the course of construction many telephone conversations and site visits were necessary to work through the various details that emerged while trying something new and out of the ordinary. All of the hurdles encountered with REMOTE were to the exterior side of the building enclosure. This difference was quite noticeable when compared to the earlier work with the on-site shear wall panels, which required more attention to detail on both sides of the enclosure.

During Phase 1which represented 25 houses, the average air tightness of the conventional homes tested near 3.0 air changes per hour at 50 Pascal's (ACH50) when depressurized with a blower door. The REMOTE dwelling tested at less than 2.0 ACH50 using the same protocol.

THRHA believes that this type of wall system is less expensive to construct labor wise, and appears to offer them a more moisture tolerant wall section. During the first summer and winter, temperature and relative humidity data loggers were installed in the exterior wall of the REMOTE wall and inside the exterior wall cavity of a conventional home. The data logging verified the perceived thermal improvement with regard to reducing condensation occurring in exterior northern climate walls.

Long term energy costs compared to the standard wall assembly are still a work in progress. But optimism is large enough for THRHA to continue adapting the REMOTE in upcoming construction projects.

Constructing the REMOTE wall assembly with a lower installed R-value, but with better control from thermal conductivity, the Tlingit-Haida REMOTE home was able to meet the State of Alaska, energy rating with 4 Star+ on the points scale. This is the same rating as they achieved with the conventional building system.

Inline Ventilation

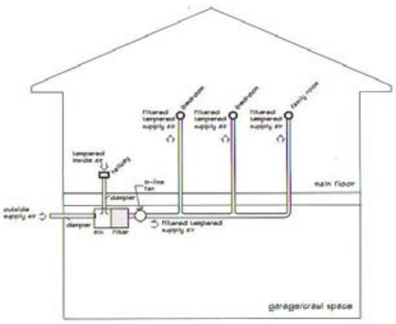
Again working with THRHA we were able to design and integrate installation of a two-fan system to deliver filtered and tempered fresh air to each bedroom, provide continuous exhaust air from each bathroom, and make available continuous crawl space exhaust ventilation.

This system originally came from a discussion with Dr. Lstiburek to find an easy way to depressurize our crawl spaces. In Phase 1 of the Glacier Village subdivision, the design goal was to locate the exhaust side of the fan system in the crawl space, while the supply side was to be located in the attic.

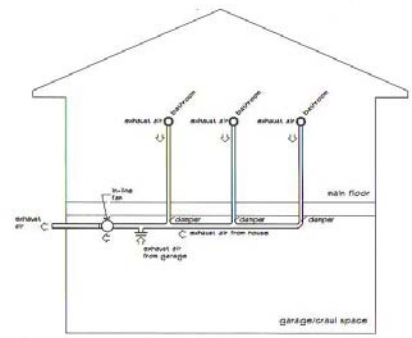
Initially the local building officials were apprehensive to allow mechanical ventilation of the crawl space due to concerns with the reliance on electricity and homeowner awareness instead of traditional passive ventilation. Monitoring of the mechanical ventilation effectiveness has been ongoing and presently the local code officials believe this mechanical ventilation system to be superior to the traditional passive approach of crawl space ventilation.

The first design approach proved to be difficult to detail proper air sealing with the ceiling air and vapor barrier. Also, at first we had not thought of incorporating filtration, just tempering of the incoming air. It did not take long to realize that installing both fans in the crawl space was much less labor intensive, plus more energy efficient. The addition of filters was another part of the continuing tweaking between the Building America Alaska team along with the staff and crew of Tlingi-Haida Regional Housing Authority.

From this experience with THRHA a new continuing education module has been created to enable other builders ways to incorporate this system. To date, this class has been offered in numerous Southeast communities under a Cooperative Extension energy efficiency education grant.



SUPPLY AIR DIAGRAM



EXHAUST AIR DIAGRAM

Appendix A

Quarterly Reports and Newsletters

Building America in Alaska II (updated 9/27/04) www.cchrc.org

CCHRC was awarded a second grant from the Department of Energy for a State Energy Program Special Project award to continue our work on the Building America program. The goals are: 1) to develop builder's education courses on BAA approaches to residential construction and to continue education and promotion of Building America techniques to the Alaskan building industry; 2) testing and monitoring of the Building America houses constructed in Alaska in 2001 to assess their performance; and 3) to develop a Building America strategy to address the cold, wet climate of Southeast Alaska which will include construction of a test module for testing wall panels for moisture, durability and energy efficiency. The CCHRC Mobile Test Lab (MTL) was constructed in North Pole and shipped to Juneau in January 2003. Students of Construction Technology at the University of Alaska SE constructed and monitored various wall systems in the test module for a year. MTL photo The REMOTE wall out performed other wall sections in terms of drying. Marquam George has sent in his reports from Southeast Alaska and CCHRC is compiling all data into a final report. Homes employing Building America technology are being constructed in Fairbanks, Wasilla, Kenai and Juneau. CCHRC is currently seeking funding to construct another MTL to monitor walls in other areas of Alaska.

REMOTE (updated 9/27/04) www.cchrc.org

CCHRC, through a grant from Alaska Housing Finance Corporation, is conducting a study to determine the efficacy of a modified PERSIST (Pressure Equalized Rain Screen Insulation Structure Technique) building envelope due to industry interest in both the dry and wet climates of Alaska. The modification relates to the roof structure and the resulting technique is referred to as REMOTE (Residential Exterior Membrane Outside-insulation TEchnique). Whereas the PERSIST Homes in Alberta, Canada have incorporated the roof into the same type of design as the walls, the Alaskan models will use a conventional energy truss and tie the wall membrane to the interior ceiling air/vapor barrier. The REMOTE design is an attempt to eliminate moisture intrusion or condensation from degrading the structural components of a building. The test homes were photographed and video recorded during construction with voice-over added later to produce a DVD, which is available from CCHRC. Monitoring and cost comparisons have been completed. PowerPoint presentations have been made at the 2003 CCHRC Annual Meeting, the Affordable Comfort Conference, the Interior Alaska Building Association, the Alaska Building Science Network Annual Meeting, and at a Canadian Housing Conference in Dawson City. Several REMOTE homes in Fairbanks, Anchorage and Juneau are under construction this season.

PRESS RELEASE March 19, 2003 Mobile Test Lab Delivered To UAS

The Cold Climate Housing Research Center (CCHRC) located in Fairbanks, Alaska delivered a Mobile Test Lab to the University of Alaska Southeast (UAS) Technical Education Center in Juneau on Monday, March 3, 2003. The Lab will be used to test different types of wall sections for resistance to moisture problems. A major challenge in the wet and windy climate of Southeast Alaska is building homes that will keep the wood in the walls and roof dry and therefore not subject to rot. The Mobile Test Lab was constructed with grant funding from the Department of Energy's Build America in Alaska program. Under this grant CCHRC is testing and promoting advanced building techniques that will allow homebuilders in Alaska to construct more energy efficient, durable, and healthy homes.

By the end of school on Tuesday, two construction technology students at UAS had designed and built a rugged set of stairs to provide access to the Mobile Test Lab (MTL). On Wednesday students were installing a heat recovery ventilator in the workshop area of the lab to control airflow and, with the aid of a humidifier, the relative humidity in the test lab. By late Wednesday afternoon a weather station was ready to begin transmitting data to a remote terminal that records outdoor and indoor temperature and relative humidity, wind speed and direction, barometric pressure, dew point, and rain fall. A small photovoltaic panel powers the weather station.

Soon, under the tutelage of Marquam George, Assistant Professor of Construction Technology at UAS, the students will design and construct a number of different wall sections that will be installed in the test bay of the Mobile Test Lab. The wall sections will be monitored for a full year to see how they perform in Juneau's wet, windy weather. The moisture content of the walls will be monitored, along with temperature and humidity inside and outside of the Lab.

The Mobile Test Lab (MTL) is designed to be moved around the State of Alaska to test walls, windows, doors, ventilation equipment and so on. After testing walls, or windows, or doors, for a year or two in Juneau it will be shipped by ferry to other communities in Southeast Alaska to continue the search for affordable, durable, safe, and healthy building components for buildings in Alaska. The MTL can be barged by sea or river to rural villages or towed to any community on the road system to take a critical look at present building practices with an eye to developing Best Management Practices for housing construction in all regions of the state.

The 8'x 8'x 24' Mobile Test Lab is constructed of fiberglass reinforced plastic/ plywood glued to a 3" urethane foam core and mounted on a custom trailer fabricated by Brett Rotermund, proprietor of Bulletproof Trailers of North Pole, Alaska. The Lab can test nine different 4'x 8'wall panels at one time or perhaps identical pairs of walls on the north and south sides to see how wind and weather affect performance. More Mobile Test Labs will be built as money comes available. The project manager for the Building America in Alaska program is Mike Musick of Ester, Alaska.

The sponsors of the Mobile Test Lab include the Alaska State Homebuilding Association, Alaska Housing Finance Corporation, Fannie Mae Corporation, University of Alaska Southeast, U.S. Department of Energy Building America, and the Cold Climate Housing Research Center.

PRESS RELEASE Building Green in North Pole Alaska

January in North Pole was cold, very cold. A week of -40 temperatures combined with low snow cover drove the frost level deep into the ground. Hundreds of gallons of heating fuel were consumed while families vainly tried to heat poorly insulated, leaking homes. Giant ice dams and stalactites of icicles ooze from roofs all over town. But the Cold Climate Housing Research Center in Fairbanks, Alaska is working to advance Alaska's building industry and is providing solutions to Alaska's housing demands. One of the newest developments has been the completion of the Building America in Alaska program.

Doug and Erica Dvorak and their son Craig enjoyed warmth and energy savings in the first Building America in Alaska prototype house to be built in this challenging northern climate. The project was a cooperative effort involving the Cold Climate Housing Research Center, the U.S. Department of Energy's Build America Program, the Alaska Housing Finance Corporation, the Building Science Consortium, and Alaska's building industry. Based on the DOE Building America Program, which was designed to promote community scale housing that use 30%-50% less energy, cut construction time and waste by half, improve productivity, and increase durability, the Building American in Alaska Program has combined the best of building science and product innovation to design affordable, energy efficient housing suitable for Alaska's sometimes hostile conditions.

The Dvorak's home has a five star plus rating and a number of construction features designed for optimum performance in North Pole's cold dry climate. Built by Steve Bee Construction it received the 2001 Governor's Award for Energy Efficient Design and Construction. Most importantly the Dvorak's love it, with a fuel consumption averaging at 3 1/2 gallons a day for domestic hot water and heat during the coldest part of winter, the house is cheap to run and easy to enjoy.

The builders, architects, and engineers who have come together to create the Building America in Alaska guidelines adapted elements of the National Building America program to meet the additional insulation needs of Alaska's climate. Like all Building America homes, the project uses advanced framing and insulation methods to increase efficiency and comfort while decreasing costs. The plans call for 2 x 6-inch studs instead of 2 x 4-inch studs, set 24 inches apart instead of 16 inches. This framing technique allows more room for thicker insulation, enhances the strength of the house, and reduces thermal bridging through the studs. It also reduces the overall amount of wood used during construction and because 30% fewer pieces have to be assembled, framing takes less time and labor costs are significantly lower. The floor was constructed using engineered floor joists, and the roof with cantilever trusses. These pre-assembled components both conserve natural resources and save time. Oriented strand board (OSB) sheathing was used on the corners, floors, and roof. OSB provides a green alternative for using small trees by incorporating them into durable wood products.

The foundation was built with insulated concrete filled forms. The insulation value of these easy to use materials is R20. In addition a 2" foam skirt was laid around the perimeter of the house. By using materials efficiently, they reduced construction costs and were able to reinvest these savings in additional energy-saving features.

Combinations of taped sheathing systems, airtight sealing of the vapor barrier, and better workmanship lead to lower air infiltration rates and reduce heating and cooling loads on mechanical systems. Mechanical ventilation is added to ensure adequate fresh air for building occupants. The Dvorak's house contains a Lifebreath HRV (Heat Recovery Ventilator) that provides ventilation and climate control in the otherwise closely sealed house. The design also incorporates energy-efficient windows. Low-emissivity coatings and vinyl frames provide much higher levels of thermal insulation than standard windows with clear glass and aluminum frames.

The Building America in Alaska home calls for R-values of 47 in the ceiling and 31 in the walls. This is achieved by adding an additional 2" of foam to the outside of the walls and blowing 17" of fiberglass insulation into the roof structure. The windows have a minimum R value of 4.3. The careful design, engineering and construction of this Alaskan home is sure to keep the Devorak's and other Alaskan home owners warm and happy well into the future.

As temperatures rise, ice melts, and a new construction season begins, the Cold Climate Housing Research Center is providing designers and builders with valuable information and detailed designs for improving performance, decreasing cost, and protecting our environment for future generations.

By Monique Musick

Greetings:
The Home Show season is in full swing in Alaska. I sat at a booth at the Juneau Building Association Home Show last weekend and talked to hundreds of folks interested in the latest building techniques appropriate for Southeast Alaska. I had brought along a display of photos and construction details of new homes designed and built by Interior Alaska Building Association (IABA) members Steve Bee and Jack Hebert. These demonstrate some exciting new building methods being developed and tested by the Cold Climate Housing Research Center (CCHRC) under the auspices of the US Department of Energy Building America Program. The REMOTE wall system designed by Jack is especially suited to building in Southeast Alaska where moldy, soggy, and rotting building materials don’t have a chance to dry out. In this wall system all of the thermal envelope, including the vapor barrier, are exterior to the structure. All the joists, studs, and structural sheathing are kept warm and dry and never reach dew point temperature and therefore never experience condensation problems. I was able to show the results of

current research being undertaken at the University of Alaska Southeast in Juneau demonstrating that the REMOTE wall system was the only wall out of nine wall systems being tested that actually showed a drying trend. All eight of the other wall systems increased in moisture content with several being above 90% RH. This research is being conducted in a Mobile Test Lab that was constructed by CCHRC with funding from the DOE Building America Program. Students in the UAS construction technology class built the test panels and are conducting the research. Results will be posted on the CCHRC website. I will be at the Ketchikan Building Association Home Show next weekend sharing the results of this ongoing research.

The IABA sponsored Northern Living Home Show in Fairbanks is March 26, 27, & 28 at the Carlson Center. Once again booth space for the show is sold out. This is the biggest event of the year for our association. The Northern Living Home Show has become a major community event for people interested in every aspect of northern living. Over 7,800 people came through the doors last year, and we are expecting even more to attend this year. The Home Show is a wonderful venue for IABA members to interact with members of the community. Show your support for the association and attend the Home Show. Learn the latest from fellow members and other vendors at their booths and at the ongoing seminars sponsored by the Alaska Housing Finance Corporation.

This year's Home Show theme is Ring Around the Roses. Thanks and roses are due to Kris Knutson for making this such a great community event. Thanks and roses are also due to Sasha and Bonnie for their tireless efforts on behalf of the association and for their work to get the 2004 Home Construction Directory done on time to distribute at the Northern Living Home Show.

Help celebrate the 20th anniversary of our Home Show and take time to smell the roses at the Carlson Center the last weekend in March. See you there!

Sincerely,

Mike Musick

Published – March 2004 – Interior Alaska Building Association Newsletter

Appendix B

Monitoring of Wall Drying Characteristics in a Temperate Rain Forest Environment

By Marquam George

Introduction

The cool and wet climate of Southeast Alaska is often at odds with the building code. Building codes require that the moisture content of the construction lumber be no greater than 19% at the time of installation in a building. Routinely the moisture content of the framing lumber used to construct buildings in this maritime region exceeds 19%.

Problems from excessive built-in or stored moisture within a building enclosure include twisting and warping of framing materials, nail popping, paint peeling, reduced thermal performance of fibrous insulation, structural deterioration from mold and mildew and concerns with reduced indoor air quality.

Additionally, the building code requires an interior vapor retarder of less than 1.0 permeance to be installed. This combined with an exterior mean relative humidity above 80% raises the question, "How well do the typically constructed walls dry in this environment?"

Methodology

The University of Alaska Southeast Construction Technology program at the Juneau campus undertook this task by conducting an assessment of typically constructed walls for moisture retention, durability and energy efficiency. This project was funded by the Cold Climate Housing Research Center, and supported by a consortium including: the United States Department of Energy-Building America, Alaska State Homebuilding Association, Alaska Housing Finance Corporation, and the Fannie Mae Corporation.

The Cold Climate Housing Research Center (CCHRC) constructed and shipped a mobile test lab to Juneau in March 2003. This mobile test lab has the capability to monitor nine different walls under the same interior conditions. The Southeast Advisory Committee of the CCHRC selected the wall assemblies for assessment. This committee represented regional builders, housing authorities, code officials and the engineering and architectural design community. The wall assemblies were tested concurrently within the test lab attempting to create identical drying potential for all the panels. Walls with similar attributes were installed and oriented within the lab so exterior exposures would be comparable.

Objectives

Evaluate the drying potential and effect of commonly constructed wall assemblies in a controlled environment. Specifically:

1. Identify the variation in drying times of selected wall panels, wetted to 30% moisture content, without re-wetting.

2. Identify wall assemblies that dry faster.

3. Identify if the tested walls dry mold-free.

Mobile Test Lab and Environment

A nine-panel test lab with exterior dimensions of 24' long by 8'-6" wide and 8'-10" high was constructed by Bullet Proof Trailers of North Pole, Alaska for CCHRC. The trailer was constructed similar to a structural insulated panel system using 4-inch polyurethane foam sandwiched between 0.5 inch exterior grade plywood and covered with an acrylic coating. The lab has four test bays on each of the two long sides of the trailer, and one wall alone on the end of the trailer. Each test wall module is 45 inches wide by 89 inches high. The test lab interior was conditioned to simulate a normal living environment. Temperature for the interior of the lab was controlled with electric resistance heaters to achieve 70°F, an intermittent ventilation cycle of 20 minutes per hour was used with a heat recovery ventilator and to simulate occupant moisture release, a room humidifier was installed and set to maintain 50% relative humidity.

To determine the drying effect of the individual wall modules, each wall was periodically opened and the moisture content at the bottom wall plate, common stud and exterior sheathing was recorded. The walls were built and installed in the mobile test lab in April 2003. Moisture measurements and visual inspections were recorded in September 2003, January 2004, and June 2004.
The tested walls were constructed at 16 inch on-center framing with the structural sheathing installed vertical to each panel. The top and sides of each wall assembly were sealed with a cross-laminated vapor retarder, even if the wall did not include a plastic vapor retarder in the test. This was done to ensure that wall drying would be directed through the structural sheathing or the vapor retarder/gypsum side of the wall. If the wall was not to have a plastic vapor retarder, this side and top retarder would be sealed to either the framing or the gypsum board. The bottom plate of each wall was left unsealed and installed in a sheet metal pan flashing over the plywood floor. Each test bay was thermally isolated from adjoining test bays with 1" of extruded polystyrene insulation around each opening.

All walls had one non-airtight 2" x 4" outlet box installed in the center stud bay 16 inches up from the bottom of the wall. Additionally each wall had a 1/2" hole for the remote sensor cable of the data logger.

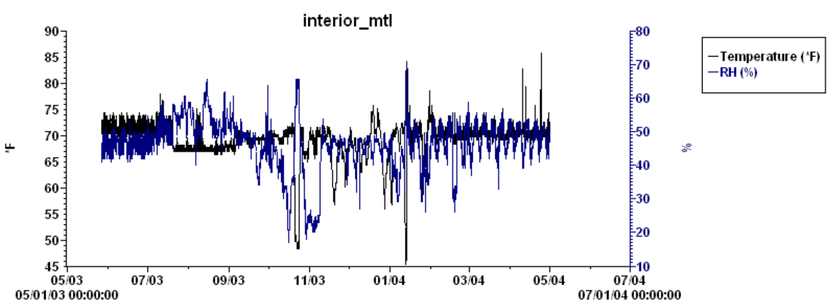
Each test wall had one HOBO® LCD Temperature/Relative Humidity data logger (Model # H14-001) installed in the center stud bay, secured to the inside of the structural sheathing 18 inches below the top plate. Moisture measurements were taken using a GE Protimeter Survey Master moisture meter.

Framing lumber was hem-fir supplied as a normal yard order from a local supplier. Prior to constructing the walls a container was fabricated to submerge all stud framing materials to reach fiber saturation.

The initial moisture content for all common framing materials was 30% and the structural sheathing was 10%.

Exterior Environment
May 2003 – May 2004

Month	Average Temp	Rainfall	Snowfall
05_2003	49.6	3.84	0
06_2003	54.6	5.5	0
07_2003	59.1	5.2	0
08_2003	56.8	6.87	0
09_2003	50.06	17.57	0
10_2003	46.1	7.53	0
11_2003	33.6	9.09	10.3
12_2003	34	11.73	20.3
01_2004	28.1	7.56	11.8
02_2004	36.5	5.58	4.4
03_2004	36.7	10.04	10.8
04_2004	43	7.39	0
05_2004	54.1	0.69	0



Average Interior Environment
May 2003 – May 2004
Temperature – 69.31°F
Relative Humidity – 46.22%

Test Panels

Wall 1

vinyl siding
Tyvek
OSB
2X6 framing
R-21 batt insulation
vapor retarder
gypsum
latex paint

Wall 2

bevel cedar siding
Tyvek
OSB
2X6 framing
R-21 batt insulation
vapor retarder
gypsum
latex paint

Wall 3

bevel cedar siding
0.5" vented furring strips
30 lb. asphalt felt
plywood
2X6 framing
R-21 batt insulation
vapor retarder
gypsum & latex paint

Wall 4

concrete board lap siding
#15 asphalt felt
plywood
2X6
R-21 batt insulation
vapor retarder
gypsum
latex paint

Wall 5

vinyl siding
3" EPS
bituthane
OSB
2X4
gypsum

Wall 6

vinyl siding
Tyvek
OSB
2X6
caulk & seal airtight drywall approach
gypsum
vapor barrier primer

Wall 7

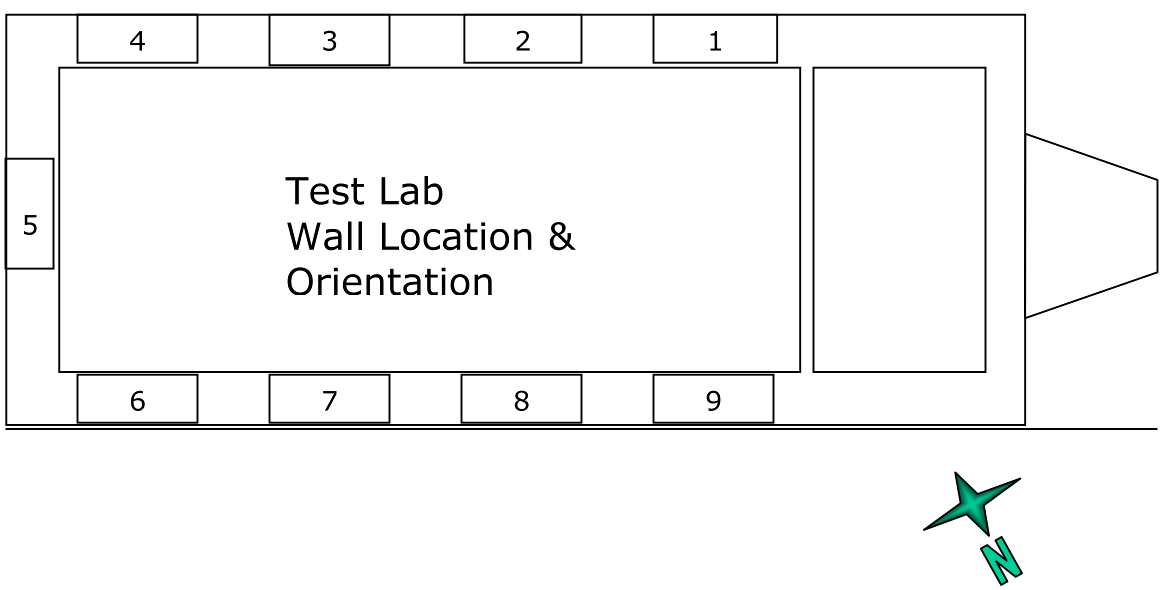
T1-11 siding
Tyvek
2X6
R-21 batt insulation
vapor retarder
gypsum
latex paint

Wall 8

Vinyl siding
Tyvek
OSB
2X6
3" spray - polyurethane foam
gypsum
vapor barrier primer

Wall 9

Bevel cedar siding
2-layers #15 asphalt felt
plywood
2X6
R-21 fiberglass batt
vapor retarder
gypsum



Wall Assembly Components and Materials

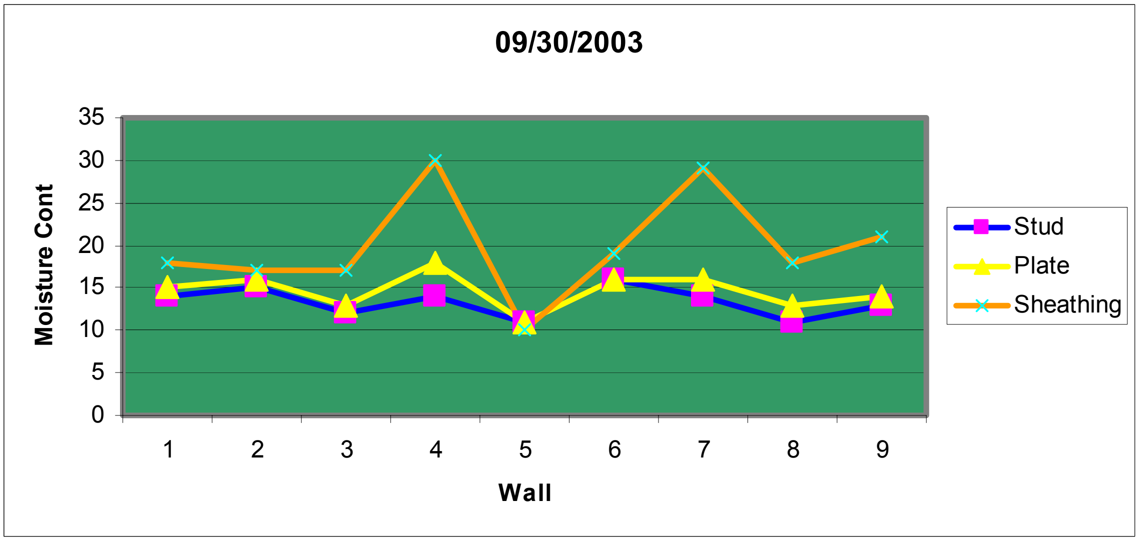
Component	Wall 1	Wall 2	Wall 3	Wall 4	Wall 5	Wall 6	Wall 7	Wall 8	Wall 9
2 x 4 Framing					X				
2 x 6 Framing	X	X	X	X		X	X	X	X
Plywood Sheathing			X	X					X
OSB Sheathing	X	X			X	X		X	
Vinyl Siding	X				X	X		X	
Cedar Lap Siding		X							X
Concrete Lap Siding				X					
T-1-11 Siding/Sheathing							X		
Tyvek	X	X				X	X	X	
#15 Asphalt Felt				X					X*
30 lb. Asphalt Felt			X						
Furred, 1/2" Vent Space			X						
R-21 Batt Insulation	X	X	X	X		X	X		X
Spray Foam Insulation								X	
EPS Foam					X*				
Bituthane Membrane					X				
Plastic Vapor Retarder	X	X	X	X			X		X
Gypsum Board	X			X	X	X	X	X	X
Caulked Drywall (Airtight Drywall Approach)						X			
Vapor Barrier Primer						X		X	
Interior Latex Paint	X	X	X	X	X		X		

Wall 5 tested using 2-layers of 1 ½ inch EPS sheathing.
Wall 8 insulated with an average lift of 3 ½ inches of spray polyurethane foam.
Wall 9 tested using 2-layers of #15 asphalt felt.

Results

The moisture content of the common wall studs and bottom plates in every assembly except wall #7 reached a moisture content of 19% or less by the end of the test period. It appears there was initially a speedy release of the stored moisture within the test panels from the measurements taken after four months of testing (09/30/2003). This liberation of stored moisture was transferred to the structural sheathing in every wall with a vapor retarder installed in the traditional manner behind the gypsum board.

The installation of the structural sheathing parallel to the wall framing members might have created a handicap of the built-in moisture being removed from the wall assemblies. Canada Housing and Mortgage Corporation have evaluated the effectiveness of drying ports for enhanced vapor diffusion in wall assemblies. Their studies showed that OSB sheathed walls with holes or drying ports had lower moisture content and increased drying, while plywood sheathed walls with holes or drying ports showed little difference.



Moisture Content Measurements of 09/30/2003

Wall	Stud	Plate	Sheathing
1	14	15	18
2	15	16	17
3	12	13	17
4	14	18	30
5	11	11	10
6	16	16	19
7	14	16	29
8	11	13	18
9	13	14	21

The drying trend of the framing members and the increased moisture content of the sheathing amplified as the test continued into the winter season. The moisture content of the sheathing reached its highest measured moisture levels during the January moisture recording. Comparison of the absolute humidity levels between the interior of the test lab, the interior of the wall cavities, and the exterior environment indicated that a significant outward vapor drive was occurring during that time.

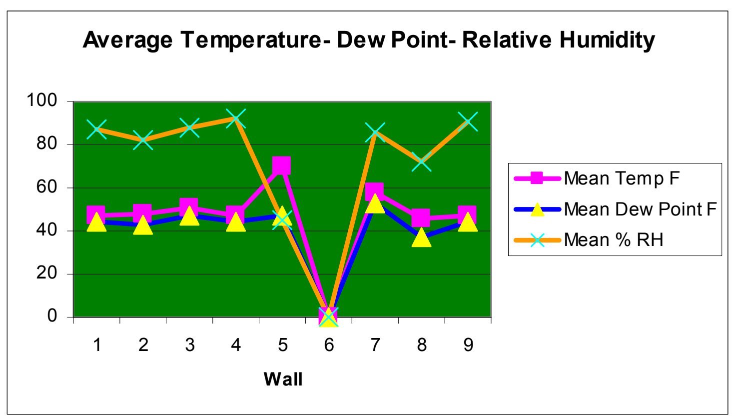
Absolute Humidity g/m³ Comparisons of 12/21/2003

MTL Interior	Wall 1	Wall 2	Wall 3	Wall 4	Wall 5	Wall 6	Wall 7	Wall 8	Wall 9	MTL Exterior
8.77	6.14	6.11	7.25	6.37	7.51	7.02	6.24	5.21	6.27	5.44
8.77	6.48	6.45	7.64	6.73	7.67	7.41	6.41	5.36	6.62	5.55
8.97	6.66	6.37	7.64	6.73	7.84	7.41	6.41	5.51	6.62	5.53
8.97	6.48	6.37	7.74	6.73	7.67	7.21	6.41	5.36	6.62	5.6
8.96	6.48	6.37	8.03	6.55	7.67	7.21	6.41	5.36	6.62	5.69
8.97	6.66	6.55	8.03	6.73	7.67	7.41	6.59	5.66	6.81	5.94
8.96	7.03	6.91	8.88	7.17	7.51	7.81	6.95	6.05	7.18	6.31
8.96	7.41	7.09	9.33	7.55	7.63	8.01	7.14	6.37	7.29	6.39
9.16	7.41	7.28	9.33	7.55	7.63	8.22	7.33	6.37	7.49	6.52

While measurements showed drying, the drying tolerance of commonly constructed assemblies appears to be less than forgiving. The temperature and relative humidity swing within the wall cavities could pose a question of long term durability of a chosen wall. Nearly half of the walls were nearing condensation conditions at the sheathing. While this study did not incorporate any window or door openings, these penetrations should only increase the likelihood of wetter conditions at the sheathing.

Average Wall Cavity Dew Point Temperature and Relative Humidity
05/01/2003 – 06/01/2004

Wall	Ave Temp F	Ave DP Temp F	Ave RH
1	47	44	87
2	48	43	82
3	51	47	88
4	47	44	92
5	70	47	45
6	0	0	0
7	58	53	86
8	46	37	72
9	47	44	91



*Wall #6 data removed due to logger failure from excessive condensation. Data logger failed 01/16/2004.

Fundamentals of moisture and structural failures have been studied and discussed for years. Structural failures due to decay of wood, while rare, have occurred. Ideally the monthly surface relative humidity of wood shouldn't stay above 80% for long periods. Perhaps the typical cavity temperature of below 50°F is just enough to balance the high relative humidity in the walls. The coldest surfaces within a wall might well be a metal fastener, nail plates or a building component. Depending on the steel, corrosion can occur from high relative humidity and most certainly be increased with liquid water from elsewhere.

Of the nine walls tested, both foam insulated wall systems out performed walls filled with fiberglass batt insulation. To go from near condensing sheathing temperatures to greater fault forgiving was measurable.

During the winter measurement and inspection, it was noted that the fiberglass batts in the stud cavities ranged from slightly damp to wet on the sheathing side of the insulation. This dampness or wetness was not evident during the final inspection, all batt insulation felt dry to the touch.

Measured moisture content of both the framing members and the sheathing was consistently greater at the bottom of the walls. This was perhaps the result of the bottom plate wicking moisture from the pan flashing and becoming a more prevailing force than convection in a small cavity. Despite the moisture measurements, the mold growth in the affected cavities was more extensive at the upper portion of the wall. Mold growth was obvious in walls, 3, 4, 7, and 9.

Some fungal growth should be expected. Depending on the environment conditions and wood species, surface mold is possible at 16% moisture content. The value of the equilibrium moisture content varies with both humidity and temperature; it is affected most by humidity. The equilibrium moisture content (EMC) of wood exposed to the average outdoor atmosphere in Juneau should be 16.31%. Based on tables from the United States Department of Agriculture, Forest Products Laboratory, Southeast Alaska would experience the lowest EMC during April, May and June, while the highest would be from September through December historically. The EMC for Anchorage would be 13.12% and for Fairbanks 11.78% for comparison.

The struggle of complying with the building code and ensuring durability was most difficult with walls 4 and 9. Both of these assemblies averaged above 90% RH and 47°F during the test period. At 90% RH and an ambient temperature of 50 degrees or less, the equilibrium moisture content would exceed 20%.

Table 1—Dependence of equilibrium moisture content (EMC) of wood on relative humidity (RH) and temperature

	EMC (%)																		
Temperature (°F (°C))	5% RH	10% RH	15% RH	20% RH	25% RH	30% RH	35% RH	40% RH	45% RH	50% RH	55% RH	60% RH	65% RH	70% RH	75% RH	80% RH	85% RH	90% RH	95% RH
30 (−1.1)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
50 (10.0)	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
70 (21.1)	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9
90 (32.2)	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
110 (43.3)	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
130 (54.4)	1.0	2.0	2.9	3.7	4.5	5.2	5.9	6.6	7.2	7.9	8.7	9.4	10.3	11.3	12.5	14.0	15.8	18.2	21.5
150 (65.6)	0.9	1.8	2.6	3.4	4.1	4.8	5.5	6.1	6.7	7.4	8.1	8.8	9.7	10.6	11.8	13.1	14.9	17.2	20.4

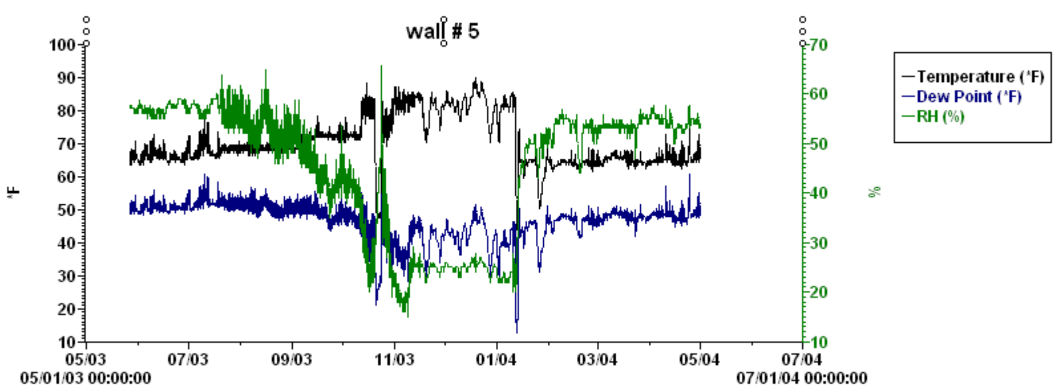
Courtesy: USDA Forest Products Laboratory
Equilibrium Moisture Content of Wood in Outdoor Locations in the United States and Worldwide

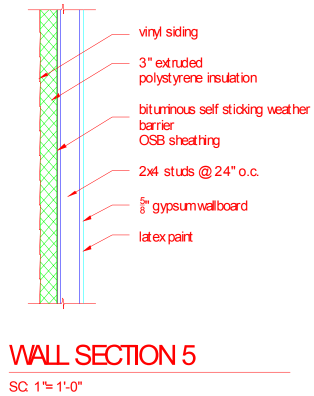
Averaging relative humidity in the fiberglass insulated walls over the year of study does not offer much improvement with the EMC. The average relative humidity and temperature of walls 1, 2, 3, 4, 7, and 9 would represent moisture content near 19%, again limited forgiveness.

Of the nine walls, the standout was most certainly wall #5. Without uncertainty it offered the most reliable approach to drying of built-in moisture.

Wall #5 is an adaptation CCHRC has been working on of the Pressure Equalized Rain Screen Insulated Structure Technique (PERSIST) from Canada. Clearly it makes sense that keeping a building warm and dry is a sensible technique.

Test Lab Wall #5





Wall #5

All insulation on the exterior on the structure.

Structural components stayed the same temperature and humidity as the ambient interior living conditions.

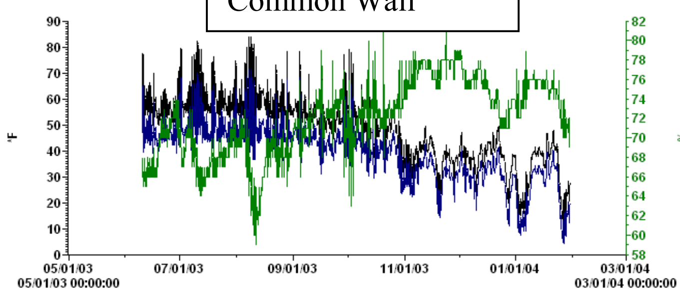
Average moisture content of framing and sheathing components : < 8%

Outside of the test lab monitoring occurred on two production houses in a Juneau subdivision during the test period. Situated on the same street with identical floor plans, orientation, and construction crew houses were constructed similar to test walls 1 and 5.

Common wall house: vinyl siding, Tyvek, plywood sheathing, 2X6 framing @ 24" o.c., R-21 fiberglass batt, 6 mil vapor retarder, gypsum, latex paint

Outside insulation house: vinyl siding, Tyvek, 3" EPS foam sheathing, bituthane, plywood sheathing, 2x6 framing @ 24" o.c., gypsum, latex paint

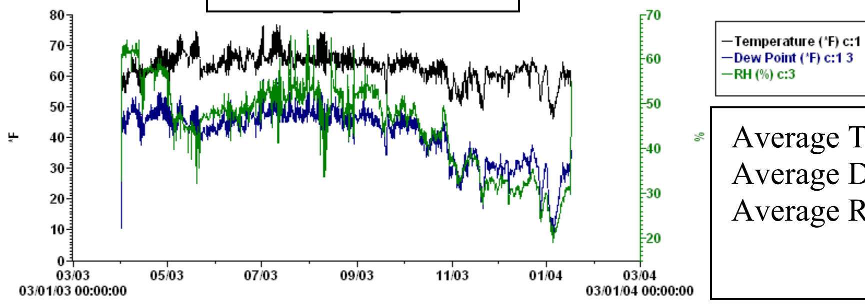
Common Wall



Average Temp 48°F
Average Dew Point Temp 39°F
Average Relative Humidity 72%

%

Outside Insulation



Average Temp 64°F
Average Dew Point Temp 41°F
Average Relative Humidity 45%

Discussion

Over the course of the assessment, four walls experienced mold growth in their wall cavities. The pan flashing installed to keep water out of the trailer in turn trapped water under some of the test walls. Sill and threshold pan flashings should be sloped to the exterior to drain the moisture. Projecting the cladding past the deck or flashing is important. Some walls shed the rain onto the flashing which affected their continued moisture loading.

The placement of space heating elements in a small space is significant to ensure uniform surface conditions. This proved difficult in keeping a stable interior temperature without getting hot and cold areas during the testing. Risk of fire from heating elements should be scrutinized carefully.

High relative humidity and liquid water protection is crucial for survival and reliability of the data loggers. Testing protocols should plan for protection of the logger or sensor from failing in a hidden space.

Conclusions

<u>Objective 1:</u>
Moisture stored within the framing components of the tested walls decreased from the worst-case start up in all of the wall assemblies.

Moisture content in the structural sheathing increased in every wall except wall #5.

The measurements of the dimensional wood products taken over this study reflect a comparable drying trend in all of the normally constructed walls.

	Moisture Content 04/.2003		Moisture Content 06/2004	
	Framing	Sheathing	Framing	Sheathing
Wall 1	30	10	13	18
Wall 2	30	10	14	22
Wall 3	30	10	13	17
Wall 4	30	10	16	22
Wall 5	30	10	8	9
Wall 6	30	10	12	19
Wall 7	30	10	20	21
Wall 8	30	10	14	16
Wall 9	30	10	14	21

<u>Objective 2:</u>
Walls with fiberglass batt insulation dry slower than walls insulated with foam, either inside a stud cavity or completely on the exterior side of the enclosure. No wall performed better than the assembly which was insulated, air and vapor sealed on the exterior of the structure.

<u>Objective 3:</u>
The issue with wicking moisture from the pan flashing clouds this objective of mold growth. Four of the 9 walls showed mold growth after one year of service. It would be an unfair assessment because of this continued wetting from the wall placement and non-sloped pan flashing to label the affected walls more prone to conditions of mold growth than the unaffected assemblies.

Managing built-in moisture is dependent on the installed moisture content and ability of a material to safely store bound moisture until vapor transfer through air movement, and or diffusion can occur before the potential for condensation takes place.

The weather barrier and requisite flashing elements must provide surface draining, protection of capillary moisture and permeability of interior moisture.

Appendix C- DVD of BAA and REMOTE

Appendix D- CD of 4-hour Building America in Alaska

Appendix E- BAAII Packet for Housing Authorities

The following introduction to Building America in Alaska was sent as a cover letter on CCHRC letterhead to 15 Regional Housing Authorities along with 3 different DOE Building America tri-fold brochures and a copy of the Interior Alaska BAA house plans.

Building America in Alaska II

Building America was started in the lower 48 by the US Department of Energy (DOE) in the late 1990's to reduce residential energy consumption. The nationwide Building America (BA) Program was established as a public/private partnership between builders, researchers, and the US DOE to reengineer the American home for energy efficiency and affordability.

The goals of the BA Program are to work with private industry to develop and implement more efficient building processes and technologies to save builders and homebuyers millions of dollars in construction and energy costs. The BA Program aims to:

- Reduce energy use by 50% below typical local construction costs
- Reduce construction time and waste
- Improve indoor air quality and comfort
- Encourage a systems engineering approach for design and construction of new homes
- Accelerate the development and adoption of high performance in production housing.

Building America was established in Alaska in the year 2000 when the Cold Climate Housing Research Center contracted with the US DOE and the Alaska Housing Finance Corporation to promote Building America in Alaska (BAA) through education and research in the design and construction of safe, healthy, energy efficient, durable, and affordable homes in Alaska. In 2001 a team of Alaskan building industry professionals collaborated with Building Science Corporation BA consortium leader, Joe Lstiburek, to design three regionally appropriate low-moderate income model homes. These designs and other designs incorporating BA details were used to construct homes in Fairbanks, Juneau, North Pole, Ninilchik, and Wasilla. Building science professionals have contracted with CCHRC to monitor the performance of these BAA homes. Preliminary reports indicate that these homes have superior indoor air quality and consume less energy than comparable homes in the region. All of these homes have sold briskly, at a profit, and have influenced builders to employ BAA techniques in other construction projects.

A brief look at Building America in Alaska II projects under the auspices of CCHRC will demonstrate the broad range of research and development sponsored by DOE and AHFC in the last couple of years. In addition to the success of the BAA design, one of the most successful projects CCHRC has completed under the BAA program is the construction of a Mobile Test Lab (MTL). The MTL was built in North Pole, Alaska by Bulletproof Trailers and delivered to the Construction Technology Center at the University of Alaska Southeast in Juneau in March 2003. The construction technology students built nine different wall configurations that they monitored for a year including the **R**esidential **E**xterior **M**embrane **O**utside-insulation **TE**chnique (REMOTE)wall system with all wood components on the warm side of the insulation and the vapor barrier. All the wood in the wall is kept warm and dry and never reaches dew point temperature. Since there is no condensation in the wall, mold, mildew, and mushrooms will not grow in this wall system.

Preliminary monitoring results indicate that a REMOTE wall system developed by CCHRC showed a drying trend over time while all other walls increased in moisture accumulation. Variations of the REMOTE wall system will be tested in the MTL for another year. In the REMOTE wall system the walls are framed using the latest in advanced framing techniques. After the structural sheathing is attached and while still lying on the sub floor a peel and stick ice and water shield membrane is adhered to the sheathing with a flap left at the bottom to lap over the foundation or rim joist once the walls are standing. The ice and water shield membrane is also wrapped over the top plate to integrate with the ceiling polyethylene vapor barrier. Two layers of rigid foam insulation are attached to the exterior of the wall with mechanical fasteners through the membrane and structural sheathing and into the studs taking care to offset the joints in the foam.

The primary Building America-Alaska partner in Southeast Alaska, the Tlingit-Haida Regional Housing Authority (THRHA), a Juneau based Native Alaskan Housing Association has constructed and is monitoring several REMOTE wall homes and has designed a four-plex using this system. THRHA, the largest homebuilding agency in Southeast Alaska, has worked with Marquam George, Professor of Construction Technology at UAS and Principal Investigator at the Mobile Test Lab, to develop a low cost, balanced ventilation system suitable for Southeast Alaska.

The latest in building science has been incorporated into a daylong builders' education program titled, *Houses That Work*, by Joe Lstiburek of Building Science Corporation under contract to the US DOE Building America Program. The HTW curriculum emphasizes moisture management as critical to improving indoor air quality and contributing to the durability of a home. CCHRC is working with DOE, the Cooperative Extension Service, and the Alaska Building Science Network to develop an Alaska appropriate version of the Houses That Work curriculum for educating builders in the 21st Century.