Measured Energy Savings from Weatherization:

Alaska vs. National Results

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Summary of Conclusions

Alaska's lower level of percentage gas savings, relative to the US cold-climate region, cannot be attributed to differences in sampling, data retention, or analytical technique using PRISM. When measured by gas consumption per degree-day, the Alaska sample of weatherized homes appears to have higher thermal integrity prior to weatherization. From different starting points, both Alaska and US single-family homes appear to be achieving a post-weatherization thermal integrity of about .155 ccf per degree day. Alaska mobile homes reach a roughly similar final level of .142 ccf per HDD, commensurate with their smaller size.

Introduction

This memorandum reviews the differences in measured energy savings from 102 Alaska weatherized homes (ISER 1993) compared with savings from a "cold-climate" region of the United States (ORNL 1993). The National study found a significantly higher level of gross energy savings (12.5%) in its sample of 1,040 gas-heated homes than the Alaska study found (5.7%) in its sample of 102 homes.

Both studies were conducted by adjusting utility billing data for changes in weather patterns using the PRISM software, and then comparing normalized energy consumption before weatherization with consumption after.

This review considers the following factors, in turn, which might explain this difference in measured energy savings:

1. Composition of the eligible housing stock
2. Screening of homes to generate the sample for analysis
3. Differences in analysis methods
4. Statistical Uncertainty of Results
5. Adjustment for Climate Differences

Review of Differences Between Alaska and National Results

For comparison with Alaska results, the cold climate, gas-heated sample of the US study is clearly the relevant comparison group. Hereafter, we refer to these cold-climate homes as the "US homes." Table 1 compares the results of the US study for this cold climate region (ORNL Table 5.2) to the Alaska results for the 102 screened homes (ISER 1993 Table 2). We focus on gross savings, without regard to the "control group" savings. (The main resaons for ignoring the control groups and associated "net" savings is that the control groups represent peoples' responses to different time periods and economic circumstances. Also, the Alaska control group results are statistically very uncertain.)

Table 1: Summary of Savings from Weatherization: U.S. Cold Climate compared to Alaska Results

Unadjusted Results	US – Cold	Alaska	Difference AK–US	% Difference
All Homes				
Number of Homes Analyzed	1,040	102		
Average Pre–Wx Consumption (ccf)	1,327	1,731	404	30%
Average Post–Wx Consumption (ccf)	1,161	1,632	471	41%
Average Savings	166	99	–67	–40%
Percent Savings	12.5%	5.7%	–6.8%	
Single–Family Homes				
Number of Homes Analyzed	929	58		
Average Pre–Wx Consumption (ccf) (*)	1,327	1,831	504	38%
Average Post–Wx Consumption (ccf) (*)	1,161	1,710	549	47%
Average Savings	166	121	–45	–27%
Percent Savings	12.5%	6.6%	–5.9%	

(*) Average values for National results are for all homes as results for Mobile homes separately are not available. Mobile homes are only 11% of sample.

Table 1 shows that Alaskan weatherized homes used 30% more gas than the US homes pre-weatherization, and 41% more gas post-weatherization. US homes saved 166 ccf/year on average, vs only 99 ccf/yr for Alaska homes. In percentage terms, the US sample showed a 12.5% reduction while the Alaska homes showed only a 5.7% reduction.

Adjustments for the Composition of the Housing Stock

One immediate adjustment to this comparison is to exclude mobile homes, because only 11% of the U.S. gas-heated sample (for all regions) is mobile homes. No region-specific mobile home percentage is available, but based on our review of the available data on the sample (ORNL tables 3.2 and 3.3) it seems reasonable to conclude that mobile homes form a similarly small part of the cold-climate sample as they do of the overall sample.

The second panel of Table 1 therefore compares US homes (including mobile homes, because we have no way of separating them out) with Alaska single-family homes. Since the Alaska results show stronger savings for single-family homes (6.6%), the difference between Alaska and US results is smaller. Alaska absolute savings are 121 ccf/yr, vs at least 166 ccf/yr for US single family homes.

This adjustment shows two things. First, the US results are basically results for single family homes, and a consistent comparison with Alaska single-family homes shows a smaller disparity in savings. Second, however, this comparison of single-family results shows that the large difference in percentage savings *cannot* be explained by the fact that Alaska homes start with a higher base consumption. In fact, US homes had higher *absolute* savings than Alaska homes. Therefore, one of the simplest hypotheses about why Alaska might have smaller percentage savings -- because it has a higher base consumption -- is not very useful in explaining Alaska's lower savings percentage.

Differences in the Sampling and Screening Methodology

The Alaska population of 508 weatherized homes (PY91 and part of PY92 -- see ISER 1993 p.6) was screened for occupancy changes. Only 15 homes were eliminated because of known occupancy changes, but an additional 201 homes were eliminated due to phone numbers being out of service or reassigned.

The US study did not specifically eliminate homes for lack of continuous occupancy, for fear of too much attrition (ORNL 1993, p. 2.13). However, the US study had to drop over 65% of the weatherized homes for which utility data was requested (ORNL 1993, p. 3.6). It is likely that much of this attrition was due to the inability to catch up with a changing customer base to obtain utility release forms or accurate billing histories.

The US study eliminated 10% of its remaining homes which exceeded certain criteria for reliability of the PRISM results. Specifically, they dropped homes where the estimate of weather-normalized consumption ("NAC") was unreliable and homes which seemed to use way too much or way too little gas. The Alaska sample had no homes which failed these criteria, so eliminations for these reasons were not an issue.

Overall, then, it appears that both studies suffered roughly the same amount of attrition in sample points due to changes in occupancy, even though the US study did not specifically control for them. It also appears that both studies ended up with similarly reliable estimates of pre-weatherization and post-weatherization normalized consumption.

Differences in Analysis

There were no significant differences in the analysis of the PRISM normalized consumption data. As we pointed out in the Alaska study, PRISM guidelines recommend dropping houses from the analysis as "unreliable" when the t-ratio of savings divided by std error of savings is low. We strongly disagreed with this theory and did not drop such data points from our study, but initially feared that the US study had employed such a procedure, which tends to raise the average savings results.

Our review of the US study clearly shows that it did *not* follow this dubious procedure. In fact, both studies used identical analyses of grouped data in determining results.

Mean vs Median Results

Although the US study did not report medians, PRISM documentation and other research suggests the use of median values rather than average values to eliminate the effects of extreme outliers. Extreme outliers would tend to have a greater effect on the small Alaska sample than they would on the larger US sample. Therefore, we computed and report in Table 2 the median values of savings for the Alaska sample of weatherized homes. Both the median value of absolute savings and the median value of percent savings are lower than the mean values, indicating that if extreme outliers are a source of bias, they are biasing the savings upward rather than downward.

Having noted these results, however, we continue to believe that the average savings are a more useful result than the median values when the purpose of the program is to reduce the overall energy consumption of the targeted housing stock.

Statistical Uncertainty of Results

Since all of the results from both studies are built up from uncertain statistical estimates, this uncertainty should be considered when comparing one study to the other. This is particularly important since the Alaska study has a smaller sample size than the US study. Generally, smaller sample sizes produce less precise results.

Table 2 of our 1993 study (reproduced at the end of this memo) showed that the Alaska results for weatherized homes had a fairly narrow confidence interval. For all 102 weatherized homes, we are 95% certain that absolute savings were between 4.2% and 7.3% of the mean pre-weatherization consumption level. So even the highest conceivable savings level (7.3%) is still significantly lower than the US result of 12.5%.

A review of the precision of the US estimates (ORNL 193, table 5.2) shows that in fact the Alaska average consumption levels were estimated more precisely than the US levels. We suspect this is due to the greater variability in climate through the year, which allows PRISM to do a more precise job of estimating how weather affects consumption. In any event, the precision of both the US and Alaska estimates is high enough that statistical uncertainty *cannot* be used to explain the difference in savings.

Table 2: Average vs Median Energy Savings from Weatherized Homes

All Homes (102 in sample):	Before Wx	After Wx	Savings	% Savings
Average gas Consumption (ccf)	1,731	1,632	99	5.7%
Std Error of Avg Consumption	12	7	14	
Median Value of Savings			69	
Median Value of Percentage Savings				4.6%

Houses (58 in sample):	Before	After	Savings	% Svgs
Average gas Consumption (ccf)	1,831	1,710	121	6.6%
Std Error of Avg Consumption	19	10	21	
Median Value of Savings			72	
Median Value of Percentage Savings				4.8%

Mobile Homes (44 in sample):	Before	After	Savings	% Svgs
Average gas Consumption (ccf)	1,600	1,529	71	4.4%
Std Error of Avg Consumption	14	11	18	
Median Value of Savings			67	
Median Value of Percentage Savings				4.4%

Adjustment for Differences in Climate

A more fundamental adjustment to the way the results should be interpreted may be appropriate when comparing Alaska to US results. This adjustment springs from the fact that the Alaska homes are in a climate with about 10,800 heating degree days (base 65), while the US cold-climate sample faces an average of about 7,500 HDD. Alan Mitchell has suggested that this difference would be further magnified if one looks at HDD to base 55, which is the temperature below which one generally needs externally supplied heat.

The significance of this difference lies in the fact that Alaska homes may simply be better insulated (before program participation) than their US counterparts, because our cold climate requires it. If this hypothesis is true, it means there may be fewer "opportunities" for savings from the Alaska program. Mitchell (personal communication, 4/6/94) suggests that much of the aggregate savings at the national level have been attributed by researchers to the saving of large amounts of energy in a small number of houses (the "guzzlers"), including houses which have no insulation at all prior to treatment.

To investigate this idea, we expressed the savings results in terms of gas consumption per HDD. An even better comparison would be ccf per *square foot* per HDD, but it appears that average house size is the same for the Alaska and US samples, and in any event the data are not available to make this adjustment.

Table 3 shows the adjusted results in terms of ccf per HDD. The table shows that the Alaska homes have a *lower* pre-weatherization gas consumption level per HDD (.160 ccf/HDD) than the US sample (.177 ccf/HDD). For all homes, Alaska also shows a lower post-weatherization ccf per HDD level. For single-family homes only, Alaska also starts out with a lower level (.170 ccf/HDD) than the US and ends up at about the same level (.158 ccf/HDD).

For single-family homes, Table 3 suggests that one reason why Alaska savings from weatherization are lower than US savings is because Alaska homes are better insulated to begin with. Weatherization measures aimed at conductive heat loss act directly on ccf per degree day, NOT total ccf. Table 3 suggests that both US and Alaska single-family homes are being brought to the same post-weatherization level of thermal integrity, as measured by consumption per degree day. Since Alaska homes start out with a lower level of consumption per degree day, there is less to save in reaching this common final level.

For mobile homes, Table 3 is not very useful since no disaggregated data are available for US mobile homes in cold climates.

Table 3: Savings Results Adjusted for Climate

	US–Cold	Alaska	Difference	% Diff.
All Homes:				
Average Degree Days base 65 (approx)	7,500	10,800	3,300	44%
Average ccf/HDD pre–WX	0.177	0.160	–0.017	–9%
Average ccf/HDD post–WX	0.155	0.151	–0.004	–2%
Average Savings in ccf/HDD	0.022	0.009		
Single–Family Homes:				
Average ccf/HDD pre–WX	0.177	0.170	–0.007	–4%
Average ccf/HDD post–WX	0.155	0.158	0.003	2%
Average Savings in ccf/HDD	0.022	0.011		
Mobile Homes				
Average ccf/HDD pre–WX	not available	0.148		
Average ccf/HDD post–WX		0.142		
Average Savings in ccf/HDD		0.007		

Conclusions and Recommendations

This review has shown that Alaska's lower level of percentage savings, relative to the US cold-climate region, cannot be attributed to differences in sampling, data retention, or analytical technique using PRISM. We have also suggested that when measured by gas consumption per degree-day, the Alaska sample of weatherized homes appears to have higher thermal integrity prior to weatherization. From different starting points, both Alaska and US homes appear to be achieving a post-weatherization thermal integrity of about .155 ccf per degree day.

Based on this review, we feel that PRISM is a valid and reliable analysis tool. Future analyses should be based on more than 6 data points where possible, even though this may mean collecting data covering more than one calendar year.

Finally, the benefits of any weatherization program must be measured in comparison with the costs. We have not been able to make this comparison at this time, and would urge caution in comparing Alaska to US results on the basis of benefits alone.

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