THE MINNESOTA ENERGY EFFICIENT HOUSE RESEARCH PROJECT

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INTRODUCTION

This research project was conducted from October 1983 to June 1985 to identify factors affecting the energy performance of energy efficient houses in Minnesota. The houses used for this study were built in 1980 under an Energy Efficient Housing Demonstration Program conducted by the Minnesota Housing Finance Agency. This program provided 144 detached and attached housing units throughout the State constructed by 23 different builders. A final report describing this work is available (Nelson, et al., 1986).

SUMMARY OF WORK AND RESULTS

1. Evaluation of Energy Performance.

The average total thermal integrity factor (based on net space heat plus internal gains) for 25 groups of houses was 3.10 Btu/ft^2-^{o}F day. This value ranged from 2.3 to 4.2. The total annual thermal load for the houses ranged from 26.1 to 54.7 million Btu/year, with an average of 41.3 million Btu/year.

2. Correlation of Energy Performance with Design Variables.

Analysis of energy consumption data for 112 houses showed few significant correlations between energy performance and design features. The effectiveness of large solar aperture or the use of night window insulation in reducing space heat energy consumption could not be proved or disproved statistically. One result, however, that did prove to be consistently significant was the loss of space heating energy due to the presence of below slab forced air distribution systems. In this case, the statistical analysis showed that these houses had an average loss of 5 to 10 million Btu/year due to the presence of below slab warm air distribution systems. These findings are summarized in Figure 1.

3. Data Base Created.

Energy consumption data for 12 months on 127 houses are included in computer files provided to Lawrence Berkeley Laboratory. These files contain the energy consumption and average weather data for each meter reading period for all houses, and include domestic supply and hot water temperatures for 47 submetered houses. Other available data are interior temperatures and information on the occupants and operation of the houses.

4. Instrumented Field Examination of Houses.

Detailed investigation of 25 houses revealed many commonly practiced housing design and construction methods that degrade the energy performance of potentially energy efficient houses. A "Slide Narrative" report containing 111 slides illustrating these findings is available.

5. Investigation of Indoor Air Quality.

Indoor air quality was investigated in 12 experimental EEHDP houses and in an equal number of control houses. Formaldehyde, nitrogen dioxide and radon were monitored. No significant differences in air quality were found between the energy efficient houses and the conventionally constructed control houses.

6. Radon Mitigation Experiment.

Radon mitigation using subfloor ventilation was found to be successful in reducing the concentration of this indoor air contaminant. Attempts to seal out radon in two control houses were not successful.

7. Evaluation of Energy Performance Computer Programs.

An evaluation of two computer programs for predicting space heat energy consumption (HOTCAN and CIRA) showed these tools to be comparable. Comparison of the measured and predicted total annual energy use yielded mixed results with measured energy uses falling within plus or minus five to ten million Btu per year of their predicted values.

8. Life-Cycle Cost Effectiveness of Four Designs.

A model based investigation of cost effectiveness compared four levels of energy efficient design for four EEHDP houses chosen to represent a range of design approaches. This theoretical approach was necessary because in actual houses the comparison of cost effectiveness using measured data would be lost in the noise created by variations in occupant lifestyle and construction quality. For each of the four designs evaluated, the level based on the current Minnesota Energy Code (which closely resembles the HUD-Mininum Property Standards) was the most cost effective for a 25-year analysis period.

9. Builder Guidelines for Energy-Efficient Housing.

Three general builder guidelines are recommended based on the findings of this research. The guidelines address the application and use of thermal insulation, the reduction of air leakage, and the design and installation of forced air heat distribution systems.

CONCLUSIONS

Overall, the houses in the research project were found to be very energy efficient. Better attention to detail, following the builder guidelines suggested in this report, could have improved energy performance even more. Based on economic evaluation, simple designs appear to be most cost effective.

B.D.Nelson, D.A.Robinson, G.D.Nelson, M.Hutchinson, Oak Ridge National Laboratory, Energy Efficient House Research Project Final Report, 1986, available from National Technical Information Service (NTIS) Report Number ORNL/Sub/83-47980/1.

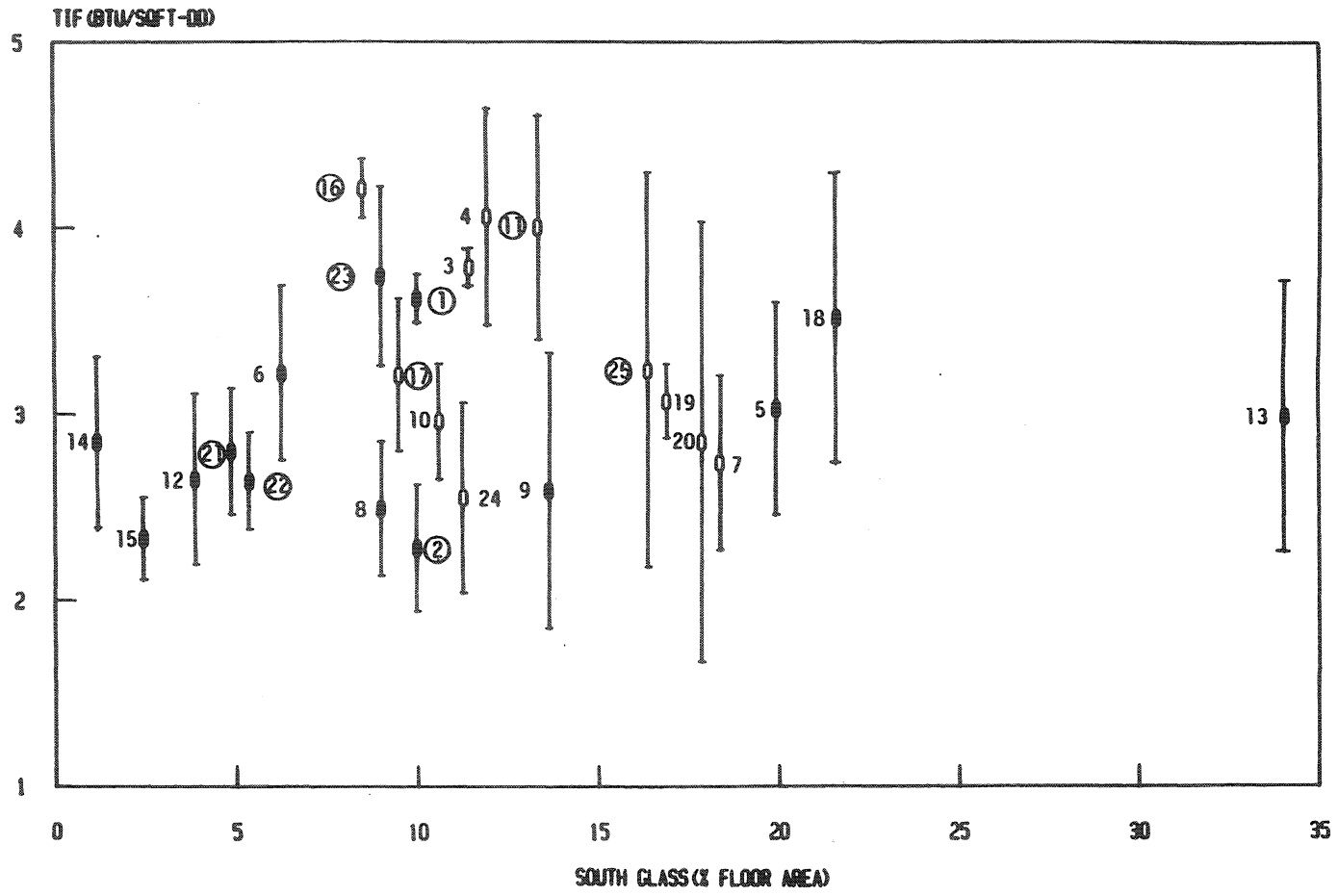

Figure 1
Thermal integrity factor for 25 groups of houses.
Thermal integrity factor includes all metered energy thermalized within the house envelope, corrected for gray water loss and metabolic gain. Mean and standard deviation of energy performance is shown for each house group. Closed and open circles represent air change rates less than or greater than the overall average of 5.3 AC/H @ 50 pa. House groups with below slab air distribution systems are shown by circled group numbers.