A QUANTITATIVE PROCEDURE FOR EVALUATING HOME ENERGY RATING SYSTEM (HERS) CALCULATION METHODS

SERI

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SUMMARY

Building energy simulation models were used to develop a quantitative procedure to evaluate more simplified design tools. The procedure was used to assist the Colorado Office of Energy Conservation (OEC) in evaluating computerized tools for its Home Energy Rating System (HERS). Simulations were performed with the detailed models on a series of cases which were representative of house construction in Colorado. The energy predictions from the detailed models were used to establish target ranges with which HERS methods results were compared. The cases, although geometrically simple, tested the ability of the HERS tools to estimate the individual and combined effects of envelope construction, thermal mass, direct gain windows, window orientation, overhangs, internally generated heat, and dead-band and set-back thermostat control strategies. The results showed that many of the proposed HERS methods were not appropriate for determining these effects.

BACKGROUND

The increased use of personal computers has resulted in a proliferation of building energy design tool software. A survey conducted by the International Energy Agency (IEA) listed 215 such design tools, 156 of which were developed in the U.S. (1). Some of these tools are used by states and utilities to rate the energy efficiency of buildings. Such ratings are often referred to as Home Energy Rating Systems (HERS). HERS are analogous to EPA automobile mileage ratings, or appliance energy stickers, although more complex. Builders and sellers can use the ratings for marketing, buyers benefit by being better informed, and lenders can better assess energy related operating costs.

It is not easy to determine the appropriateness of a given HERS method for a given purpose. An evaluation of a number of design tools done by the IEA showed large differences between tools, even when run by experts (2). It is important that the design industry, and HERS sponsors not become disillusioned with these tools. The potential for energy savings and comfort improvements are great through their use.

The Colorado OEC, in the process of developing a HERS for the state, was confronted with the problem of selecting the calculational basis for the HERS from responses to a solicitation. They requested SERI's assistance on this issue because SERI had for a number of years been investigating the validity of detailed building energy simulation programs (3). More recently SERI had been involved in an IEA project to develop a quantitative procedure for evaluating simplified computer based building energy design software (4). SERI intended to modify the international version of the procedure, so that it would be more relevent to buildings in the U.S.. It was decided that a specially adapted version of the design tool evaluation procedure would be included in the OEC RFP. Respondents were required to run their simplified HERS models through the evaluation procedure and submit the results with their proposals.

APPROACH

The evaluation methodology was intended to filter out grossly innaccurate tools, and tools which were not sufficiently sensitive to important building construction differences. It was not intended to validate HERS methods or design tools. The strategy was to use a number of detailed "state of the art" public domain computer programs to generate "reference" data against which the more simplified HERS methods could be compared.

Three reference programs were selected: MICRO-DOE, BLAST level 144, and SUNCODE. MICRO-DOE and SUNCODE are the microcomputer versions of DOE-2.1c and SERI-RES, respectively. These detailed simulation models were selected to provide a range of results that different modelling methodologies typically produce (SUNCODE uses a finite differencing method to model heat transfer, while MICRO-DOE and BLAST use different variations of a response factor approach). SERI-RES, BLAST, and DOE have been subjected to a number of validation studies by the U.S. Department of Energy (DOE), and by the IEA (3,5). These studies showed that the energy predictions from the "state of the art" reference programs may differ depending on the climate and building type modelled. However, in this project we chose to accept legitimate internal modelling differences (those not due to input errors or code bugs) among the reference codes to establish reasonable output value ranges. The target output ranges were compared to the results from the more simplified HERS calculation tools.

A series of cases was developed to determine the appropriateness of the HERS methods for application on the building types and climate conditions prevalent in Colorado. These test cases were included in the RFP issued by the Colorado OEC.

Three different building types, with several construction differences, were modelled in two different climates with the hourly simulation programs. These included a poorly insulated traditional brick house, a typical "stick-built" house, and a very well insulated passive solar house with internal masonry thermal storage. Each building type contained such features as a night set back thermostat, and window overhangs. The goal was to test the performance of the proposers' HERS methods across the spectrum of possible, significantly different, building types and features in Colorado. The reference programs established a target range for annual heating and cooling loads, and sensitivity to construction changes. If the proposers' tools estimates were within that range, no error was recorded. If the tool's estimates were outside the target range, the absolute value of the error was recorded and summed with the errors from all the cases.

RESULTS

Figures one and two display the annual heating and cooling predictions by the reference programs, and the HERS methods in the Denver climate. The two solid lines represent the maximum and minimum predictions from the reference programs across all the test cases. The symbols represent the predictions from the proposed HERS methods. The first two cases labeled "WOOD" represent a typical stick-built structure with a deadband, and night setback thermostat control strategy respectively. The next three cases represent a building with increased south window area, and increased mass. The first and second of the solar buildings used deadband control. The second solar building also has a shading overhang on the south window. The third solar building uses night set-back control. The final two cases represent older uninsulated double-brick construction. Window area is the same as for the non-solar stick-built case. The two parametric variations are also the same as for the stick-built cases.

In Figure 1, the HERS methods generally overpredict the annual heating loads with respect to the reference programs. The modified bin method predicts about double the heating loads for the passive cases, and shows distorted sensitivity for the massive brick cases, and for the change from the wood building to the solar building. This is to be expected since the modified bin method does not account for solar and mass interactions, and would also tend to overcalculate savings due to night setback in a massive building. The other three methods should in theory be able to account for solar and mass interactions in some fashion. Even though they overpredict heating loads, in general they exhibit reasonable sensitivity to the construction changes across the cases. The modified correlation method shows no sensitivity to night set-back because this was not a strategy for which correlations were developed in the method.

Figure 2 shows the reference codes and HERS predictions of annual cooling loads in the Denver climate. The predictions by most of the HERS methods are very different from each other and from the reference predictions. The modified bin method and the brute correlation method are consistently low, showing little sensitivity to solar gain, shading, and mass. The modified transfer function method, which in theory should be the most accurate of all the HERS methods, consistently overpredicts the target values by a large amount suggesting a bug in the code. The modified correlation method agrees best with the reference predictions. This method would have agreed better with the reference data if it had not used seasonal cut-offs for heating and cooling loads. The reference data included winter cooling loads, while the modified correlation data included only summer cooling loads. This effect was biggest in the solar building which overheated in winter more than the other building types.

CONCLUSIONS

This work demonstrated the feasibility of using detailed building energy analysis simulation programs to quantitatively evaluate more simplified HERS methods. Agreement among the detailed "reference" programs was sufficient to establish target ranges against which to compare output from HERS tools.

Tool developers should understand why their tools disagree with these target values, and should warn users of important limitations in the tool. Simplified HERS methods should be evaluated against such targets as a minimum quality assurance procedure. The outputs of the "reference" programs do not represent absolute truth. They do represent our best current knowledge of the calculation of building thermal behaviour.

None of the HERS methods tested agreed with the target values and target sensitivities for all cases. The SERI evaluation procedure provided important input for the the Colorado OEC to choose the most appropriate HERS method for the building types and features prevalent in Colorado.

New tests can be developed for the building types of interest in other states.

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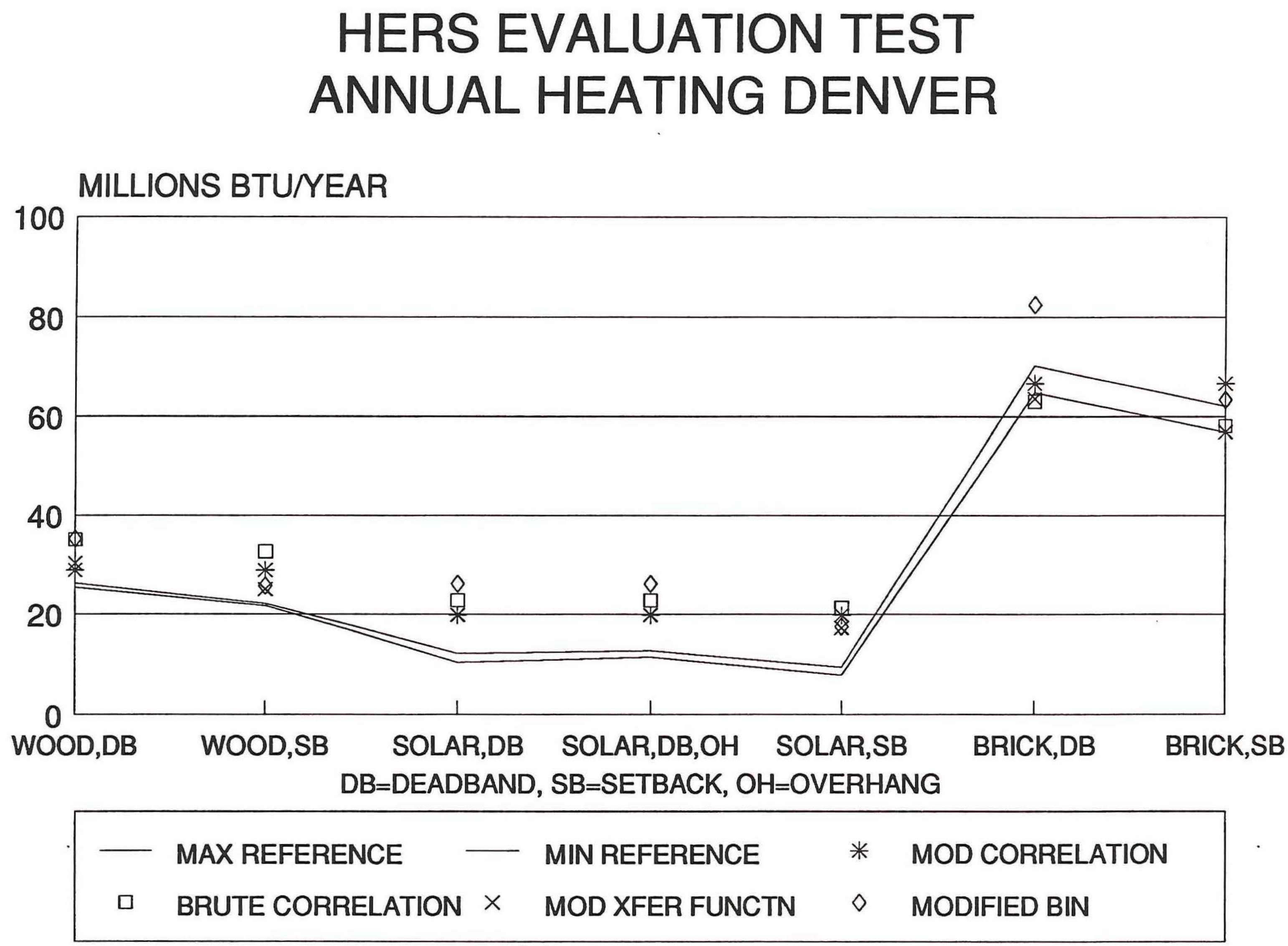
HERS EVALUATION TEST
ANNUAL HEATING DENVER
MILLIONS BTU/YEAR
100
80
60
40
20
0
WOOD,DB
WOOD,SB
SOLAR,DB
SOLAR,DB,OH
SOLAR,SB
BRICK,DB
BRICK,SB
DB=DEADBAND, SB=SETBACK, OH=OVERHANG
MAX REFERENCE
MIN REFERENCE
MOD CORRELATION
BRUTE CORRELATION
MOD XFER FUNCTN
MODIFIED BIN

FIGURE 1

HERS EVALUATION TEST
ANNUAL COOLING DENVER

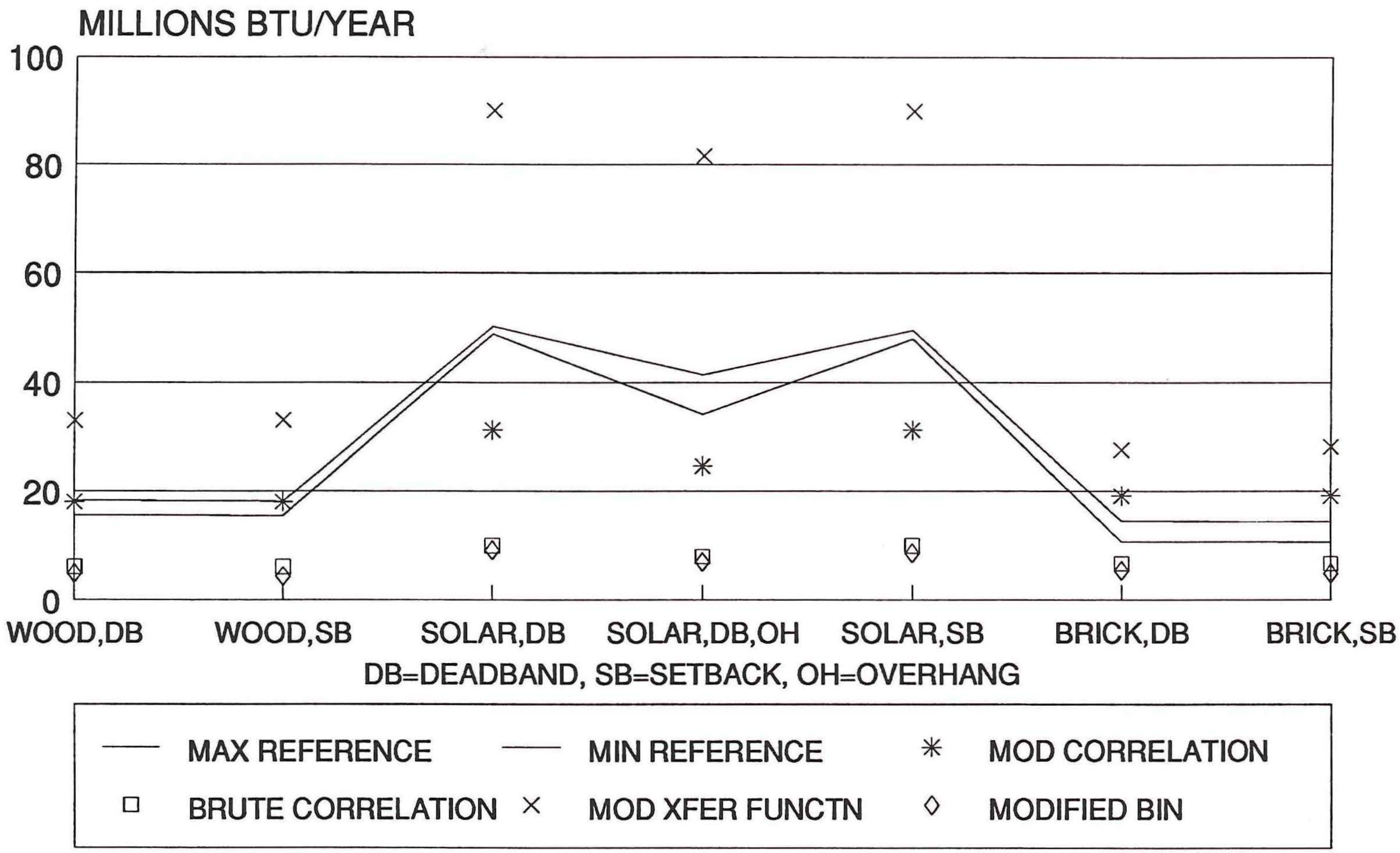

FIGURE 2