OVERVIEW OF THE HEAT LOSS STUDY FOR THE HOOD RIVER CONSERVATION PROJECT

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The Hood River Conservation Project has collected extensive submetered data in electrically-heated houses before and after the installation of weatherization measures. The goal of the Hood River Heat Loss Study is to compare the measured space heating energy use and weatherization savings with the annual use and savings predicted by two models, SUNDAY and the Standard Heat Loss Methodology (SHLM). This paper describes the scope of the entire Heat Loss Study, scheduled for completion in December 1986, and focuses specifically on issues that surfaced during the first stages of an initial trial study.

Data available for analysis comes from 246 single family houses that are monitored for total electricity use, space heating electricity use, and interior temperature. Interior temperature is monitored in one room only, usually the living room. One hundred sixty-three of these houses are also monitored for hot water electricity use, while the remaining 83 are monitored for woodstove heat output. All information is gathered at 15 minute intervals. The woodstove monitoring system, a remote radiation sensor, was developed at Lawrence Berkeley Laboratories. Site-specific correlation factors must be determined for each stove in order to translate recorded pulse counts into equivalent kilowatt-hours of heat output.

In addition to the sub-metering, extensive ancillary data on these houses has been collected. Occupancy characteristics, a listing of weatherization measures that were installed in each house, and energy audit information, including initial insulation levels and air-tightness of the house, are all part of the data base. Weather and solar data were collected at three representative sites in the project region. This allows a close match to actual weather conditions when working with the thermal simulation models.

The first of the two thermal analysis models being compared with the monitored data will be SHLM, a modified degree day method. This technique was developed by Bonneville Power Administration for use by energy auditors in estimating energy savings from residential conservation measures. Annual use is predicted by multiplying the house UA times heating degree days times a generic C-factor. SHLM uses pre-defined component U-values to represent base case conditions of the house. U-values are changed to reflect the retrofit condition of the house and post-weatherization use is estimated. Weatherization savings are calculated as the difference between annual use pre- and post-weatherization. Actual heating degree days monitored at the weather sites are used in the calculations. UA-values and heating degree days are the only explicit drivers of SHLM; the C-factor is used to represent all other factors, such as solar gains, internal gains, and room closure, that adjust estimated space heating use. The C-factor is

empirically derived through analysis of monthly billing data from a sample of all-electric homes within the BPA region.

The second model, SUNDAY, is a micro-computer energy simulation model developed by Ecotope, Inc., which uses daily weather and solar data to simulate the heating and cooling requirements of single-zone residential buildings. SUNDAY is similar to SHLM in that it calculates heat loss based on the overall UA of the house. In constrast to SHLM, the SUNDAY model requires detailed inputs; among them are internal gains (including people but excluding solar gains), thermostat set point, building thermal mass, and window direction and shading. Data measured in the Hood River Project approximates some of these parameters but interpretation must be applied in order to use them in the model. For example, a temperature monitor in the living room of a baseboard heated house does not necessarily reflect the thermostat set point of the whole house as defined by the simulation model.

While the goal of the Hood River Heat Loss Study is to compare these models against measured use in all 246 houses, an initial study was started to develop inputs to the SUNDAY model with a smaller, simpler set of houses. For the preliminary study, the number of houses investigated was reduced from 246 to 38 based on the following criteria: no basement, no wood heat, and one full year's worth of pre-weatherization monitored data. In addition, any house whose energy use profile was anomalous (for example, no space heating in December) was also excluded, leaving a clean set of 25 houses with which to work. This initial study focused on defining appropriate inputs for the SUNDAY model. The biggest questions were what to use for the thermostat set points, what to use for internal gains from appliances, and how to determine building UA-values, given the incidence of closed off, unheated rooms and uncertainties about adjustments to component U-values.

The thermostat setpoint is a critical input to the SUNDAY program: initial studies indicate that predicted space heat energy use decreases 4-5% for each degree F decrease in setpoint temperature. Out of 25 houses in the subset, 22 had baseboard heaters, which are conducive to zonal heating. Two factors are particularly important for determining a single set point appropriate for the simulation model from a single temperature sensor that was generally located in the living room. First, living room temperatures are not necessarily indicative of temperatures in other rooms, especially in baseboard heated houses. Secondly, temperatures will float above the set point. As a consequence, a number of methods are still being explored for determining an appropriate single set point for the entire house.

Internal gains from appliances were estimated using 95% of the monitored base load plus 1400 kwh/year if the water heater was in the heated space and 700 kwh/year if it was reported to be in an unheated location.

More than half of the houses in the initial study had reported room closures during the heating season. The level of detail in the original audit, which included a rough map of the house, enabled an adjustment of total building UA-values. This was accomplished by identifying a circuit of

series and parallel heat flow paths and applying thermal network analysis to this circuit. Results from the 13 houses with reported room closures in the sub-sample of 25 houses suggest a linear relationship between the percentage of closed off area and the percent reduction in total building UA-value. The percent reduction in UA was also compared to the fraction of closed off rooms in the house; this data is more scattered. Similar calculations must be done with houses in the full sample to give a statistically significant basis for generalization.

A final complication in the initial pre-test concerns identifying the appropriate overall house UA-values. Prior studies by Judkoff, Wortman, and Burch[1] indicate that standard engineering values can cause prediction errors in auxiliary loads on the order of 60%. In addition, sol-air effects are quite large in fairly uninsulated buildings, and this is not incorporated in the overall house UA. Further exploration of this topic is expected as the Hood River Heat Loss Study proceeds.

Once accurate SUNDAY inputs for the small trial sample are determined, an effort will be made to generate inputs for the full sample of houses. A major challenge for modeling all the sub-metered houses is to determine how to incorporate space heating from wood stoves into the SUNDAY simulation estimates and to assess the reliability of the wood heating data. Measurements taken near the end of the two year monitoring period show that some of the radiometers have been moved and that some of the stoves do not match the geometry upon which sensor correlation parameters were originally based.

The final results of the Hood River Heat Loss Study will be available in December 1986. The models examined in the study are particularly important to energy planning and conservation acquisition in the northwest region: SUNDAY is used by the Northwest Power Planning Council to develop estimates of cost effective conservation potential available from weatherization measures in new and existing residential buildings, while SHLM is used by the Bonneville Power Administration to evaluate the cost effectiveness of retrofit weatherization measures in existing houses.

1. Judkoff, D.N. Wortman,and J. Burch, "Empirical Validation Using Data from the SERI Class A Validation House", SERI/TP-254-1928, April 1983.