THE D.O.E. SLIDE RULE: AN ENERGY CONSERVATION ESTIMATING TOOL FOR HOMEBUILDERS

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ABSTRACT

How much insulation should be placed in the ceiling of a home? Which furnace is the best investment? Is reflective glazing a marketable option? The DOE slide rules and accompanying guides are designed to help answer such questions by providing a way to measure the impact on home energy use of a variety of energy conservation options.

The whole kit is designed to be accurate and easy to use. It provides guidance on energy efficient construction practices, and a means to quantify them by using the slide rules. An economic analysis is also suggested. The work aims at transferring high level research to non-technical users: homeowners, builders and lenders.

INTRODUCTION

The Department of Energy (D.O.E.) slide rule is an easy-to-use energy conservation estimating tool, developed along with several other conservation guides collectively entitled Affordable Housing Through Energy Conservation and Affordable Manufactured Housing Through Energy Conservation. The objective of these guides is to help homebuilders sell more energy efficient houses by quantifying the resulting reduced cost of homeownership. The slide rules were developed in a joint effort by Steven Winter Associates, New York City and Lawrence Berkeley Laboratories, Berkeley, California.

The guides in general and the slide rule in particular were designed, in a larger sense, to help solve one of the main problems facing the national energy conservation effort today: the limited utilization of proven, energy saving technology and building methods in the nation's new buildings. The result of extensive research conducted after the 1976 passage of the "Energy Conservation Standards for New Buildings Act" indicated that significant reductions in the nation's energy consumption by buildings were feasible. However, obstacles within the marketplace and problems in technology transfer have prevented many such possible reductions.

In the residential sector, two specific obstacles to energy-conserving design have prevailed. First, the housing industry has lacked the resources needed to take advantage of existing energy conservation design methods, which typically require extensive calculations, weather data, etc. Second, homebuyers have often been unwilling to pay the generally higher purchase price of an energy-conserving home because they have had no reliable means of determining whether any given home will in fact use less energy and reduce costs in the long run.

The D.O.E. slide rule removes these obstacles by providing builders, lenders, and homebuyers with an inexpensive, easy-to-use tool for estimating the energy savings that will result from adding energy conservation options to a home.

The following is a more detailed review of the slide rule, its design and its functions.

THE DOE SLIDE RULE: AN OVERVIEW

The D.O.E. slide rule has been developed to estimate the energy savings associated with a range of conservation features for conventional, wood frame homes and manufactured homes. The wood frame house types include ranch, two-story split level homes, and townhouses. The manufactured house types include single and multi-section models.

The slide rule is a consolidation of over 12,000 individual simulations using the DOE-2 computer program. The accuracy of the slide rule in estimating energy savings is, therefore, greater than most manual, calculator and microcomputer tools and yet a calculation can be performed in a few minutes by a layman.

The basic approach taken in using the slide rule is to begin with a typical home (of any of the types listed above) and to use this as a "Comparison Home" to which various energy conservation options are added. The options include:

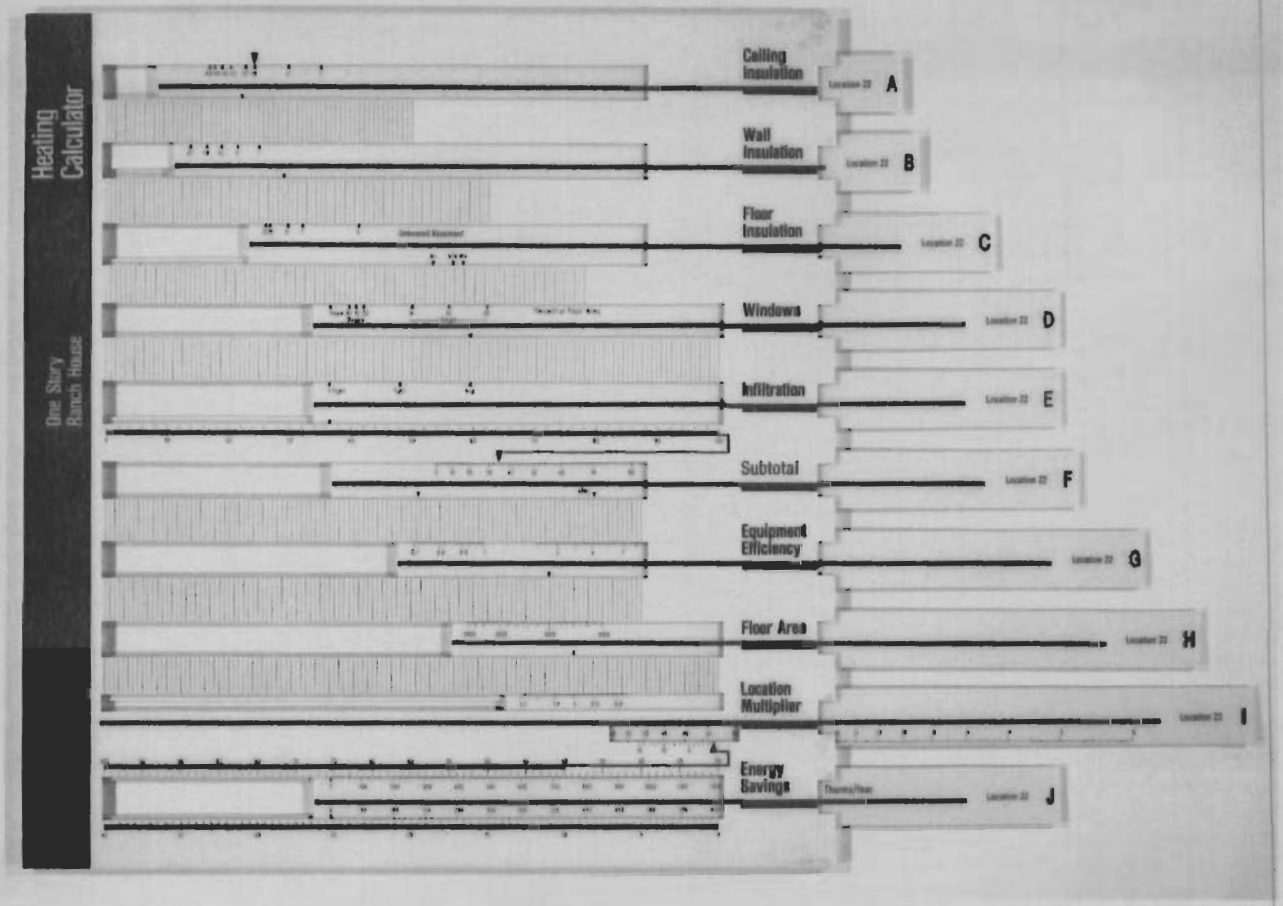

FIGURE 1 "AFFORDABLE MANUFACTURED HOUSING THROUGH ENERGY CONSERVATION": SLIDE RULE HEATING CALCULATOR

1) increased ceiling insulation
2) increased wall insulation
3) increased floor insulation
4) reduced outside air infiltration,
5) better insulated windows
   - o multiple glazing
   - o improved sash
6) more efficient heating/cooling equipment

The energy savings of each conservation option is then measured relative to this Comparison Home and the savings are in turn compared to the actual costs of each option.

For instance, a builder in Topeka, Kansas is considering offering a home for sale with R-19 insulation in the ceiling. After identifying potential homebuyer options to increase the ceiling insulation level (such as using R-22, R-30, or R-38 instead of R-19), a quick estimate is made of the energy savings that will result from adding each of these options to the home. By comparing these savings with the costs for each option, the builder can identify the most marketable of these energy savings measures and offer them as options to the homebuyer.

Additional energy conservation options not quantified on the slide rule can be assessed by use of a set of accompanying "modifiers". "Modifier" options are addressed in the guides and include:

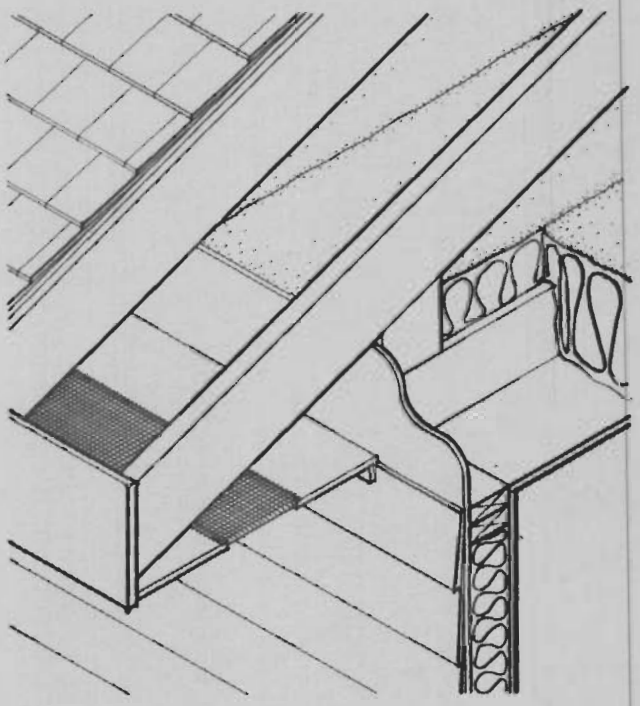

FIGURE 2 "AFFORDABLE HOUSING THROUGH ENERGY CONSERVATION"; CEILING DETAIL

1) varied window orientations
2) thermal mass for passive solar designs
3) heat absorbing and reflective glass
4) movable insulation
5) roof and wall color variations
6) attached sunspace
7) automatic night setback thermostat
8) improved domestic hot water system

The impact of each modifier is expressed by means of tables or multipliers. Simplicity of use was the driving force behind the selection of presentation.

The slide rule is made applicable to all areas in the country by the use of 45 climate specific "tab sets". Each "tab set" contains energy data for a "primary" location within the climate zone. There are, however, over 3,000 cities and towns associated with the 45 primary locations. A Location Multiplier tab serves the purpose of tallying the results for each of these additional cities; it is used in conjunction with Location Multiplier tables, made available in the Guides. The tables contain a list of cities with the associated climate zones and location multipliers. "Primary" locations have location multipliers of 1.0, while others take values varying between 0.5 and 2.0.

The builder selects the appropriate location multiplier from the Guide and uses it on the slide rule to amend the results. For example, one set of tabs is for Houston, and the location multiplier can fine-tune the Houston energy consumption figures to be applicable to College Station.

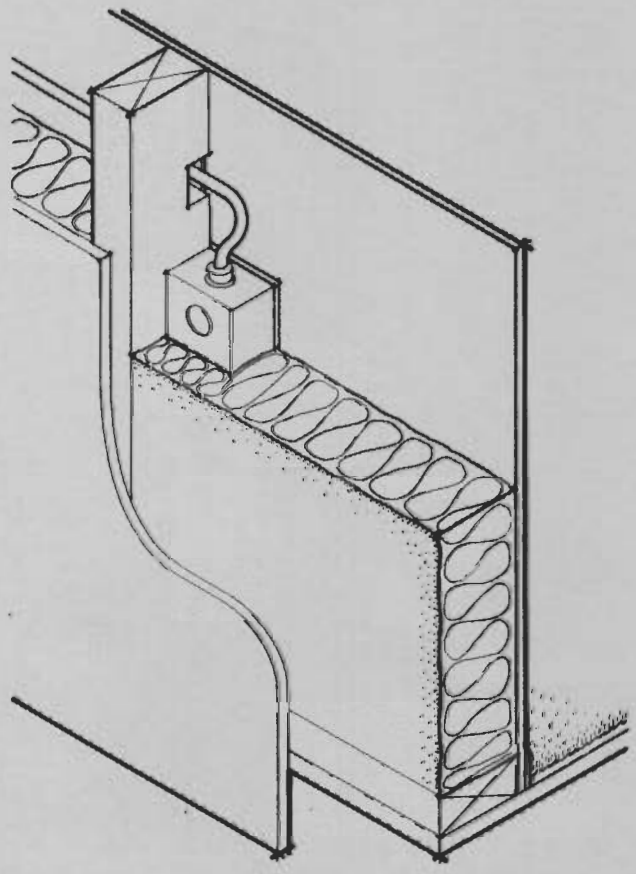

FIGURE 3 "AFFORDABLE HOUSING THROUGH ENERGY CONSERVATION"; WALL DETAIL

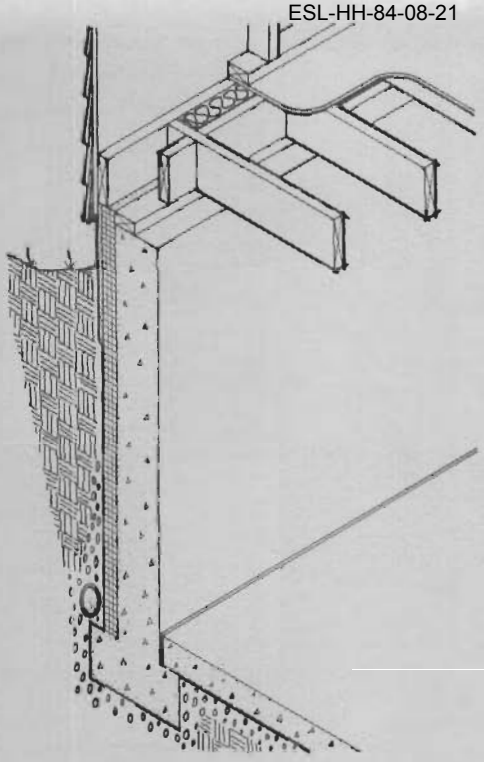

FIGURE 4 "AFFORDABLE HOUSING THROUGH ENERGY CONSERVATION"; FOUNDATION DETAIL

Each slide rule has two sides, a heating side and a cooling side. The Heating Calculator is used to estimate heating energy savings, while the Cooling Calculator provides estimates of cooling savings. In calculating the energy savings associated with a specific conservation option, such as additional insulation in the ceiling, both sides of the slide rule must be used if both heating and cooling equipment are provided in the home.

Along with equipment efficiencies and the other energy conservation options utilized, total energy savings is dependent on the fuel type used. The slide rule allows for the use of the correct fuel type for the specific application by providing fuel type "tabs", for each of the major energy types currently available (natural gas, oil, electric, or liquified petroleum gas).

The Guides contain a comprehensive set of drawings and instructions on energy efficient construction. This information complements the slide rule and is organized following the order of the tabs: ceiling, wall, floor, etc. There is a definite benefit to these approaches; the user is able to judge the economic merits of an energy conservation option and is provided with guidance on how to implement it.

The discussion on the benefits of energy conservation is be accompanied by certain clarifications. Quality of construction, weather, occupant behavior vary.

The value of the energy savings is an estimate of the annual fuel saved by implementing a certain energy conserving option. It is useful for comparison purposes only. That is, the actual energy usage of an individual home in the same location may vary depending on the size of the family, how many times doors and windows are opened and closed, or any of a wide range of other factors. It is best to think of the savings as you would of an EPA mileage estimate: it is useful to compare one home with a certain set of options against another with different options, but, as in the case of automobiles, the actual mileage, or energy usage for the home can vary from the slide rule estimate.

This is a problem that all energy estimating tools face. Like any other projection, what is sought is reasonableness, given that total accuracy is impossible to obtain.

What the slide rule achieves is a very close estimate of the energy savings, within a simple graphic format. Even without using it, one can see at a glance which energy conservation option is more beneficial: The larger the distance between two pointers, the more energy is saved. The law of diminishing returns applied to increasing R-values is made obvious in an intuitive manner. This is the power of a pictogram: it conveys more information and much faster than other types of communication. Just by taking a look at the slide rule, one can see that while insulation is important for heating, windows and equipment are most relevant for cooling. In this way, worthwhile energy conservation options in any given climate may be quickly recognized.

There are certain drawbacks associated with the presentation format. The number of options, although large, is nonetheless limited. The same graphic format that enables rapid decisions hampers the achievement of great accuracy. The reason: The density of the scales must be reasonable in order to obtain good readability. Here, the intended audience shaped the trade-offs between precision and useability. It was reasoned that the 3rd digit after the decimal point would make little difference to a builder, banker or architect.

This non-abstract, easy-to-grasp presentation should help the dissemination and acceptance of energy savings features and enable more people to make an informed choice when buying, building or financing a house.

REFERENCES

1. "Affordable Manufactured Housing through Energy Conservation", US Department of Energy to be published August 1984.

2. "Affordable Housing through Energy Conservation", US Department of Energy to be published December 1984.

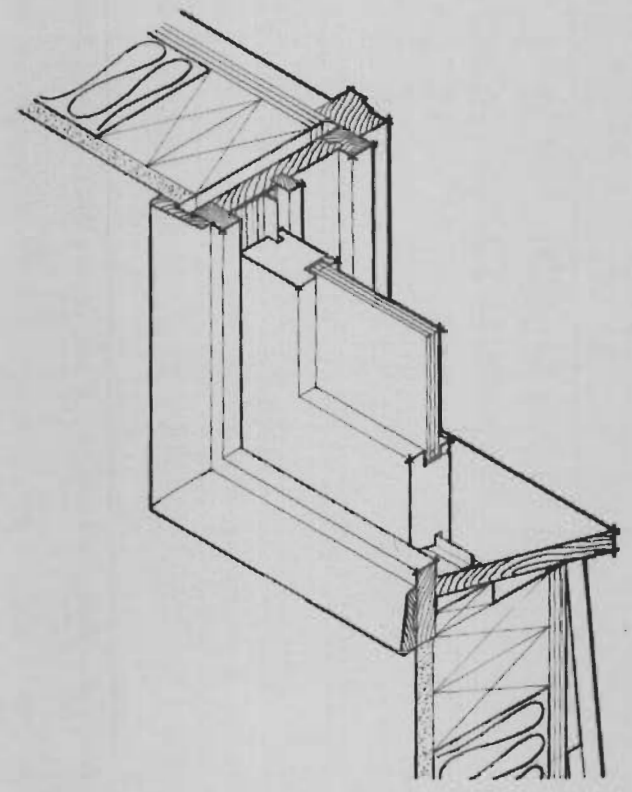

FIGURE 5 "AFFORDABLE HOUSING THROUGH ENERGY CONSERVATION"; WINDOW DETAIL